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ERRATA.

Page 328, line 6 from bottom, *Eulima Staloi*, read *E. Stalioi*, Brus.
„ 654, line 20 from bottom, *Tremapora*, read *Tremopora*, Ortm.
„ 665, line 6 from bottom, *Membranipora hydasi*, Jullien, read *M. Hyadesi*, Jullien.
„ 681, line 20 from bottom, "Tremopora dendracantha, *Ortmann*, *Die Japanische Bryozoenfauna*," *read* Tremopora dendracantha, *Ortmann, Die Japanische Bryozoenfauna, Arch. f. Naturgesch.* Jahrg. 56, Band i. p. 29, Taf. ii. fig. 6 (1890).

THE JOURNAL

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Notes on Bryozoa from Rapallo and other Mediterranean Localities.—Chiefly Cellulariidæ. By Arthur William Waters, F.L.S.

[Read 5th November, 1896.]

(Plates 1 & 2.)

Although now at work upon material collected in Rapallo, near Genoa, it has seemed better to give this paper a wider range, so as to be able to include any observations resulting from comparison with my Mediterranean and other collections. In fact, it may be said to include a revision of my paper * on the Naples Bryozoa.

General questions of structure and classification have received considerable attention, but are only dealt with where there seemed sufficient reason for doing so.

When I wrote upon the Naples Bryozoa, a very large number of the descriptions, even by the leading authorities, were most unsatisfactory; nor did I possess my present large collection, including preparations made in various ways †, so that only limited comparisons could be made. Since then the student has had for reference, besides a large amount of general literature, Hincks's well-illustrated work on the British Marine Polyzoa, and

* Ann. & Mag. Nat. Hist. ser. 5, vol. iii., 1879.

† In all cases where I have had suitable material, stained sections have been cut, either for minute structure or, when the state of preservation has not been suitable for anything more, for the interzoœcial connexions; nor can any series be considered complete until there are stained specimens mounted whole, as well as preparations of the opercula and mandible, besides calcareous sections.

also two papers by the same author on the "Polyzoa of the Adriatic" *.

In the paper above-mentioned I showed the value of the operculum, and afterwards of the avicularian mandible, for classificatory purposes. These are now being examined by all workers; and in various papers, and especially in one recently read before the Microscopical Society, I have also shown that the rosette-plates are another important character; and now in this paper stress is laid upon noting the position of the radical fibre.

Therefore, with much extended means of study, it is not surprising that, upon re-examining my Naples material and collection, points should turn up which were overlooked or not recorded.

The greater part of the present communication relates to the Cellulariidæ. Most members of this family throw out corneous tubular radicals; and the position from which these grow is, as a rule, fairly constant in each species, so that it may be used as a specific character, or even in some may have generic importance. This, however, has been neglected, and has seldom been fully and correctly described. Also in other families more use may be made of the *position* of the origin of these tubes, by which the colony becomes firmly attached.

In the description of the species, it is now shown that in the Cellulariidæ there are two distinct kinds of articulation. In the larger number the new branch is given off from a small chamber formed for the purpose. As the type of this section, *Menipea Buskii* is figured (Pl. 1. fig. 10); and I propose to restrict *Menipea* to those forms having this kind of articulation; and it will then include *M. Buskii*, MacG., *M. crystallina*, Gray, *M. cyathus*, Thompson, *M. cervicornis*, MacG., *M. compacta*, MacG.

On the other hand, probably * *M. cirrata*, Lamx., *M. gracilis*, Busk, *M. patagonica*, Busk, *M. funiculata*, MacG., *M. triseriata*, Busk, *M. flabellum*, L., *M. ternata*, Ell. & Sol., must, on this account, be elsewhere located; and in fact, before noting this distinction, it had been felt that several species should be removed from the genus.

In another section, including *Scrupocellaria*, the jointing consists of nothing more than a partial breaking through or thinning

* Ann. & Mag. Nat. Hist. ser. 5, vol. xvii. p. 254, and vol. xix. p. 302.

† *M. cirrata* and *M. flabellum* are Lamouroux's types; but these, I think, will fall into other established genera.

of the walls of the zoœcia near the commencement of the branch. In the zoœcia in which this breaking through of the wall of the zoœcial chamber has commenced, the polypide is seen unaffected, partly above and partly below this incipient division (see Pl. 1. figs. 11, 12).

Menipea and *Bugula* are evidently very closely related; for a specimen from Florida, sent to me as "*Bugula*?" by Miss Jelly, has zoœcia with an area, just as in *Bugula*, and a sessile avicularium similar in shape and position to that occurring in *B. avicularia*, but the branches are articulated, with three zoœcia to an internode, as in *Menipea*. The jointing here occurs by breaking through or thinning of the walls without any chamber being formed; the younger parts of the branch, however, show no trace of articulation.

The Cellulariidæ are still in a state of confusion, and the genera are based upon very unsatisfactory characters. Smitt, recognizing this, united *Cellularia*, *Scrupocellaria*, and *Menipea* as *Cellularia*; but Busk and Hincks have not followed him in this. The retention of the name *Cellularia* has long seemed most undesirable, as it has been used in most various senses, and has included forms which are now placed under widely separated genera. Pallas, who gave the name *Cellularia*, had under it *Tubucellaria*, *Cellaria*, *Notamia*, *Bugula*, *Scrupocellaria*, *Eucratea*, *Aetea*, and others. With the exception of *Cellularia cuspidata* and *C. Peachii* (both of which should be placed with *Scrupocellaria*), the only other remaining species of *Cellularia* are from the 'Challenger;' but I think if we turn to Mr. Busk's definition of the genus in his Report we must consider it as an admission, on his part, of inability to find characters upon which to base it; for "zoarium bi- or tri-serial with more than four cells in each internode; with or without a sessile avicularium behind the upper and outer angle; with or without a pedunculate fornix," does not contain a single definite statement.

Then Hincks in his description says, "avicularia and vibracula usually wanting;" but of six 'Challenger' species, five have avicularia. However, since Hincks wrote this the presence or absence of avicularia has been shown in many families to be without value in generic classification. MacGillivray writes, "zoœcia biserial . . . avicularia usually absent."

As Busk in his 'Challenger' Report neither figures nor mentions the articulation when describing his species, I do not feel

able to discuss the position of his species without further examination, but think most will fall under *Scrupocellaria*, though *Cellularia cirrata* and *C. quadrata* may have to be placed in another family.

If a name which has been used in such various ways can now be buried for ever, it will be a great gain, and it now seems quite superfluous.

Among other points mentioned in the present communication is the existence of ovicells on the erect tube of *Aetea*, a genus which has always been described as without ovicells.

The stalk of *Chlidonia Cordieri* exhibits a very curious structure; for the central parenchym-cord gives off a branch to a disk about the middle of each internode.

In *Bugula plumosa* there are cases of long tubes starting from the lower part of the colony, having much the same appearance as the radicals, but at the end they produce a polypide, and in this way a new colony may arise.

Although sections have been cut wherever there was suitable material, the gland-like bodies have not been found in any of the groups under consideration; and I may now mention that nearly all the truly calcareous species have these glands, whereas none have been found in the corneous ones.

Before proceeding to the special descriptions, I must express my warm thanks to the owners of the small zoological laboratory in Rapallo (Professors L. Camerano, M. G. Paracca, and D. Rosa of Turin), for kindly placing it at my disposal during my three weeks' stay in Rapallo in March 1893; and specially thank Dr. Paracca for the trouble he took in seeing that arrangements were made. This was rather too early for satisfactory work, as a large number of the specimens brought in were not living, or were in an unsatisfactory condition for showing minute structure. This, however, was not the case with all; and I was enabled to see the gland-like body in a large number of species, and also to study the interzoœcial connexion in many.

The list of species collected some years before from the seaweeds thrown up on the beach was almost doubled, as the dredge brought up specimens which would easily be overlooked among the seaweed. The ground is mostly mud, and the neighbourhood cannot be called favourable for Bryozoa. The best places for dredging are where the mud ceases, about two or three miles out; and probably a better locality for the larger coral-like forms such as *Porella cervicornis*, *Hornera*, would be near Camogli,

where the depth is much greater but, not being as protected, the sea will often be more agitated.

AETEA ANGUINA, forma RECTA, *Hincks*. (Pl. 1. figs. 1–5.)

In Rapallo I saw, in March, a large number of specimens with a small transparent ovicell, at the top of the tubular prolongation which has been called a peristome. In most cases there were four divisions in the ovum, but in a few there were eight. The ovicellular wall is very thin and delicate; and unfortunately the material at command has not enabled me to study the ovicell and ova as fully as I hoped.

The discovery of an ovicell is extremely interesting, as the genus has always been described as without one; in fact, Jullien * created a "tribus" Inovicellata for the Aeteidæ; but classification based upon the absence of a character is always rather risky.

What Mr. Hincks calls the zoœcium in this family, Jullien (*loc. cit.* p. 25) would call the peristome. Now, while Jullien is correct in refusing to call this tubular prolongation a zoœcium, it does not seem that this tube, which has a hinged opening at the termination, should be compared with a peristome, which is a prolongation beyond the opercular opening. Jullien seems to fancy that he was the first to notice that the polypide did not live entirely in this part, but was also in the portion which Mr. Hincks speaks of as the "elongate subfusiform body." On reference to Smitt's figures †, and to my figure and the text of the same paper ‡, he would have seen that it had been appreciated that the polypide is not only lodged in the upright portion, as Busk erroneously believed, but is also in the lower part. I think that both Hincks and Jullien must have overlooked my paper. In one case in which the ovicell contained a large unfissured ovum, the tentacles and stomach were mostly in the tubular prolongation, and the fusiform body was nearly filled up with the ovarium in which there were at least four young ova.

Aetea truncata also occurs near Rapallo §.

* 'Mission du Cap Horn,' p. 23.

† Hafs-Bry. Utv. 1865, pl. ii. figs. 11, 12.

‡ Ann. & Mag. Nat. Hist. ser. 5, vol. iii. p. 114, pl. xv. fig. 7.

§ I have to add to the list given in my paper on the "Bryozoa of Naples,' and a supplementary one given in a note to a paper in the 'Transactions of the Microscopical Society,' ser. 2, vol. v. p. 6, the following Neapolitan species:— *Aetea truncata*, Landsborough; *Bugula spicata*, Hincks; *B. ditrupæ*, Busk; *B. neritina*, L.; *Scrupocellaria Bertholletii*, Aud.; *S. Delilii*, Aud.; *S. in-*

Scrupocellaria reptans, *L.*, var. Bertholletii, *Aud.* (Pl. 1. figs. 18 & 19.)

Acamarchis Bertholletii, *Audouin in Savigny's Égypte*, pl. xi. fig. 3.

Scrupocellaria Bertholletii, *Hincks, Ann. Mag. Nat. Hist.* ser. 5, vol. xvii. p. 258, pl. ix. figs. 1–2.

This only differs from *S. reptans* in having a less-developed scutum, for the zoœcial characters and the shape is the same in both, and in the type and the variety there are three or four external spines; the chambers for the avicularia and the radical fibres are exactly similar, as is also the ovicell and the terminal disks of the radical. At the bifurcation, in both, there is a single vibraculum.

To return to the scutum: this is very variable, and I have specimens where some zoœcia have no scutum; in others it is small bifurcate, then again some are larger bifurcate or cervicorne, while in *S. reptans* occasionally the scutum is only bifurcate, other zoœcia showing gradations to the fully-developed characteristic scutum. When previously working on the Naples Bryozoa I came upon this, and made a note of it as a variety of *S. reptans*, with but slightly-developed scutum, but do not seem to have considered it worth describing. Both forms occur at Naples, Capri, Rapallo, and Trieste, and the variety probably came from Egypt. Jullien * says that he has obtained *Scrupocellaria reptans* with lateral avicularia; but in the specimens of both the type and the variety in my collection, from various places, this seems to be common; and Hincks, in his 'British Marine Polyzoa,' had previously mentioned this character, which had been overlooked by older writers. On account of these lateral avicularia Hincks had removed it from *Canda*, where it had been placed by Busk. *S. reptans* has two lateral rosette-plates, and Levinsen says that *scruposa* and *scabra* have also two. *S. Delilii* and *obtecta* have the same number, while in several species of *Bugula* there are four lateral plates. In the Cellulariidæ this character would seem to be of *generic* rather than of specific value; whereas we have seen that in *Flustra* the *specific*

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curvata, Waters; *Beania hirtissima*, var. *robusta*, Hincks, and var. *cylindrica*, H.; *Schizoporella armata*, Hincks; *S. magnifica*, Hincks; *S. marsupifera*, B.; *S. ambita*, Waters; *Hornera lichenoides*, Pontop.; *Entalophora clavata*, Busk; *Buskia socialis*, Hincks; *Retepora complanata*, Waters; and *Palmicellaria parallelata*, Waters.

* Mission du Cap Horn, p. 69.

differences in the number and form of the rosette-plates are very considerable *.

Of the seven Mediterranean species of *Scrupocellaria*, all except *S. incurvata* and the variety *Bertholletii* occur elsewhere. *S. reptans*, *scruposa*, *scrupea*, and *inermis* are Northern, while *S. reptans* and *scrupea* are also found in the Australian seas.

SCRUPOCELLARIA DELILII, *Aud.* (Pl. 1. figs. 14, 15.)

Crisia Delilii, *Audouin in Savigny's 'Description de l'Égypte,'* p. 242, pl. xii. fig. 3.

Scrupocellaria Delilii, *Busk* (*non Alder*), *Q. J. Micro. Sc.* vol. vii. p. 65, pl. xxii. figs. 1–3.

Specimens from Naples, Rapallo, and the Gulf of Taranto belong most undoubtedly to the species figured by Savigny. The two converging spines are characteristic. Most colonies have no frontal avicularium, and in those that have it is only found on some zoœcia. In one good colony there is only one, and that on a zoœcium just below a bifurcation.

The zoœcium at each bifurcation has a central spine, a character which Mr. Hincks mentions in *S. scabra*, but which seems to be fairly common in the genus, as it occurs in *S. scrupea*, *S. Bertholletii*, and *S. reptans*. On the dorsal surface at the bifurcation there are two vibracula, whereas in *S. scabra* there are none; but the most important distinction between the two species is in the vibracular chamber, which is much narrower and longer than that of *S. scabra*, and the rooting attachment is more directly under the vibraculum.

It will thus be seen that *S. scabra* remains a Northern form not yet found south of the British Isles, while *S. Delilii* is Southern, occurring in the Mediterranean and Madeira. The internodes are much longer than those of the Mediterranean *S. scrupea*.

This is closely related to *S. Macandrei*, but from the figures in the 'Challenger' Report they would seem to be distinct.

SCRUPOCELLARIA SCRUPEA, *Busk*.

There are two vibracula at a bifurcation similar to those which Levinsen has described as occurring in *S. scruposa*. The only other species in which I have found two are *S. ornithorhynchus*, *Delilii*, and *incurvata*. The small avicularia, by the ovicells, are similar to those which Levinsen describes on *S. scruposa*. These

* "Interzoœcial Connection in *Flustra* and other Bryozoa," Journ. Roy. Micro. Soc. p. 279, pls. vii. & viii. (1896).

had previously been overlooked, as they are very minute, and being on the inner side of the ovicell are in most positions of the zoarium concealed; however, when looked for, they can generally be found upon Mediterranean specimens.

The shape of the vibracular chamber and of the chamber for the insertion of the rooting-fibre is the same in *S. scrupea* and *scruposa*, and these species are closely allied. It may be mentioned that, while the presence of the scutum is a distinguishing character, it does not occur in all the zoœcia.

SCRUPOCELLARIA INERMIS, *Norman*. (Pl. 1. figs. 11 & 12.)

Scrupocellaria inermis, *Norman, Quart. Journ. Micr. Sc.* n. s. vol. viii. p. 215 (4) pl. v. figs. 1–3; *Kirchenpauer, Jahresb. Comm. wissensch. Unters. d. deutschen Meere,* Jahrg. ii. & iii., 1875, p. 180.

A fine stained and decalcified specimen, collected in Trieste, is figured, as it shows so well the way in which the articulation is formed, for in the zoœcium at the bifurcation the polypide is seen on both sides of the articulation, proving that this is a break formed in mature zoœcia. Although the object of the figure is to explain this structure, it will be as well to also consider the species systematically. This specimen has no median avicularia, and the lateral one is much smaller than in Norman's figures. There are no spines and no scutum; whereas, as I have shown *, *S. elliptica*, Reuss, has both, and therefore the two specific names must be retained. The vibracular chamber is small, and appears to be narrower than in the specimens described by Norman, but being decalcified a complete comparison cannot be made. This chamber is much shorter and wider than that of *S. scruposa*, and the chamber for the insertion of the radical is distinctly separated, both chambers being about the same width.

The vibraculum is very delicate, but I should scarcely call it short. At a bifurcation there is only one vibraculum; thus it is distinguished from *S. scruposa*, in which there are two. Pergens says † that *S. scruposa* form *elliptica* is found at Palavas (Dépt. de la Hérault) and at Banyuls. Presumably it is this species; but as there has been confusion between *S. elliptica*, Reuss, and *S. inermis*, Norm., we cannot be certain without a re-examination.

* "North Italian Bryozoa," Quart. Journ. Geol. Soc. vol. xlvii. p. 6, pl. i. figs. 16, 17.

† "Notes sur les Bryozoaires," Ann. Soc. Roy. Malac. Belgique, vol. xxiv. p. 7.

SCRUPOCELLARIA INCURVATA, sp. nov. (Pl. 1. figs. 16, 17.)

Specimens from Naples in most respects resemble *S. Delilii*, but the branches of the zoarium are stouter, with a much larger scutum extending beyond the opesium. There is usually a spine at each upper corner converging as in *S. Delilii*, Aud. Also the median avicularia are similar to those of *S. Delilii* and the ovicell is entire; but the two can be distinguished by the vibracular chambers, for in the present species they are somewhat oval, extending half across the zoœcium, with the groove turned inwards, and the pair of vibracular chambers at a bifurcation have similar curved grooves. It will be seen that this curved groove, though not as large, is similar to that of *Caberea*, and, except on account of the difference in the oral aperture, it is difficult to see any reason for separating the two genera.

S. scabra, *Delilii*, and *incurvata* seem to be a natural group, distinguished, however, by striking differences in the vibracular chambers.

In the whole of the Cellulariidæ one of the most useful specific characters is the way in which the radical fibre is attached, for in each species there seems nearly always to be some definite position from which it starts in all zoœcia. In *Scrupocellaria* and *Caberea* it grows from a chamber at the base or side of the vibracular chamber. In *Menipea aculeata*, *M. Buskii*, *M. cirrata*, and *M. funiculata* the radical arises from the base of the internode; whereas in *M. cervicornis*, *M. compacta*, and *M. ternata* var. *gracilis*, it arises from the top. It is, however, not only in the Cellulariidæ that the position of the radical is a useful character, but in the description of all rooting forms it should be mentioned.

CABEREA BORYI, *Aud.*

The oval body to which I refer in my paper * on gland-like bodies (p. 277) occurs constantly in the Rapallo specimens. It is rather smaller than in those from Trieste, and stains deeply and uniformly.

There is one very large avicularium below the bifurcation. This is apparent in the Rapallo, Naples, and Roscoff specimens, and also in one from Adelaide which I consider to be *C. Boryi*. It appears to have been overlooked in this species, but somewhat similar avicularia in the same position have been figured in *C. rostrata*, B.

* Journ. Linn. Soc., Zool. vol. xxiv. p. 272.

C. Darwinii, Busk, dredged by the 'Challenger' from Nightingale Island, is very similar to the European *C. Boryi*, as the vibracular chambers are identical in shape, so are the avicularia both lateral and median. The character by which the two species are distinguished is that in *C. Boryi* there is a calcareous bar below the proximal border of the oral aperture, and to this the upper part of the scutum is "soldered," while in *C. Darwinii* (Pl. 1. figs. 13, 21–25) the scutum is free and there is no bar right across the front, though sometimes it has commenced at both sides, thus showing us the early stage of *C. Boryi*. The 'Challenger' specimens do not show the helicine mark on the scutum to which MacGillivray refers. The differences are so slight that I should have called *Darwinii* a variety of *C. Boryi*.

Caberea Boryi, however, also occurs in the Southern hemisphere, from New South Wales, Adelaide (Victoria), and New Zealand; but in all these the lateral avicularia are somewhat larger than in the European specimens.

In *C. Boryi* there is one vibracular chamber at the bifurcation. There are 13 tentacles.

In *C. Darwinii* there are two spines at the lower edge of the oral aperture and two at the distal.

Bugula plumosa (*Pallas*). (Pl. 2. figs. 5–7.)

See *Hincks, Brit. Mar. Polyzoa*, p. 84, for synonyms.

Bugula plumosa, var. aperta, *Hincks, Ann. & Mag. Nat. Hist.* ser. 5, vol. xvii. p. 261, pl. ix. fig. 6.

Bugula simplex, *Hincks, loc. cit.* p. 262, pl. ix. fig. 7.

This seems to be subject to a certain amount of variation in the matter of spines. In some they are scarcely distinguishable, in others the outer one attains a moderate size. Again, on the inner corner of most specimens no spine can be found, in others only a protuberance, while, again, in some it is distinct. In Trieste I noticed that those collected in the sea had a fairly prominent outer spine, while those growing in the aquarium had only a protuberance; and there seems to be no difference in the colonial growth of the *B. simplex* form and the *B. plumosa* form from this locality. I have from Trieste typical specimens of both forms, but upon examining a series I am unable to separate them *.

* In an undoubted *B. plumosa* from Roscoff, occasionally a slight prominence on the inner border may be detected.

From Rapallo I have the *plumosa* form with the small cap-like ovicell of the variety *aperta* of Hincks, and it occurs on both the forms from Trieste; but from analogy with other Bryozoa it would seem possible that the remarkably small ovicell may be a stage of growth; that is to say, the ovicells are only in the initial stage. We may in colonies of Bryozoa find the ovicells in every stage of growth; on the other hand, this is not always the case, for I have specimens of *Retepora* in which most zoœcia show the small semicircular plate, indicating the commencement of the ovicell, though none have complete ovicells.

If more abundant material should show that I am wrong in the interpretation of these points, then we have *B. spicata* var. *aperta*, *B. spicata*, *B. plumosa* var. *aperta*, and *B. plumosa*—all living side by side; but if these are to be specifically separated, it must be upon other distinctions than those at present indicated.

The primary zoœcium has a central spine at the base of the area *, and on each side two spines near the distal end. It is not only the first zoœcium which may possess ancestral characters, but two, three, or even more uniserially arranged may have the same shape before the normal zoœcia are formed; and in this species there are sometimes near the base a number of zoœcia longer than the normal ones, but with the area very short. The repetition of the ancestral characters in the few first zoœcia we may see in *B. avicularia*, *B. calathus*, and *B. neritina*; and further, in *B. plumosa* from a single zoœcium zoœcia may spring out at each side and form new branches, but this does not seem to be a common method of increase.

Another mode of increase is of great interest, and was found in colonies growing in the aquarium of the Zoological Station in Trieste—some basal zoœcia producing either direct (Pl. 2. fig. 7), or from lateral zoœcia (fig. 6), long processes which seem scarcely to differ from the radicals, or attachment fibres, except in being rather stouter. These processes may equal ten zoœcia in length, and at the end a young polypide buds, and in some cases from

* I term this "area," for "aperture" seems eminently unsatisfactory seeing that there is no aperture, but only a thinner portion of the front wall. It might perhaps be better to term it "opesium," but at present a general term may be safer. "Aperture" is probably a relic from times when only dried specimens were examined and low powers used, and a real aperture was thought to exist.

this there is a second bud (Pl. 2. fig. 7), showing that a new colony may arise from this elongated process. This budding may occur in a colony in which the polypides are all dead, and the zoœcia only contain brown bodies, as well as in colonies in full vigour.

Bugula is without an operculum, but there is in the membrane of the upper part of the area a diaphragm, similar to the "irisoïde" of Jullien, and through this the polypide is extruded. In not having an operculum attached by muscles, this genus would seem to be widely separated from *Membranipora*, but, on the other hand, the primary zoœcia remind us of *Membranipora*. When the polypide is protruded, the front wall of the zoœcium is carried with it, so that the way in which the polypide comes out cannot be compared with most other Chilostomatous genera: in fact, it seems in this respect to have most analogy with the Ctenostomata.

On the dorsal surface, the distal wall ends lower down than on the anterior surface, and forms a sharp curve. In the above and most other species this is the only divisional mark on the dorsal surface, but in *B. dentata* there is another at the height of the distal end of the area. The space thus enclosed has a large opening and can therefore hardly be called a chamber, and is often filled with protoplasmic threads as well as the testes and spermatozoa.

Round the edge of the distal walls close to the upper border, and near the dorsal surface, there is a row of numerous small rosette-plates. These rosette-plates and the four lateral ones seem to occur in the same position throughout the genus. They have been figured by Levinsen in 'Danske Dyr,' pl. ii. figs. 5, 6.

The radical tubes are thrown off from near the base of a zoœcium.

The fact may be mentioned for what it is worth, that as a rule the *Bugulæ* in the Northern hemisphere have the avicularia placed high up on the zoœcia, whereas those in the Southern hemisphere have them near the base. *B. neritina* has them low down, and we may ask whether this form has been introduced from the Southern hemisphere.

Bugula ditrupæ, *Busk*. (Pl. 2. figs. 2 & 3.)

Bugula ditrupæ, *Busk, Q. J. Micro. Soc.* vol. vi. p. 261, pl. xx. figs. 7, 8; *Hincks, Ann. & Mag. Nat. Hist.* ser. 5, vol. xvii. p. 260, pl. ix. figs. 3, 4.

Specimens from Naples show that the "additional spine" about midway on one side of the area is not a constant character,

some specimens being entirely without while others have it to some zoœcia. This "additional spine" is found quite as frequently in the Mediterranean *Bugula calathus* as in *B. ditrupæ*. Some specimens have to some zoœcia three outside spines and two inside, while other zoœcia have three outside and three inside.

The primary zoœcium has a central spine at the base of the area, flanked by a spine on each side, and at the top of the area a pair of spines at each corner, and in more than one specimen this primary zoœcium has an avicularium; and this is the only species in which I have seen avicularia to the primary cells.

The beginning of the colony grows up straight at first, then dichotomizing from a centre forms a cup.

This is in most respects very similar to *B. spicata*, H., which I have biserial from Naples and Capri, while from Naples and Trieste it is 4-serial, and in these the outer avicularia are larger than the inner. The avicularia of *B. spicata* and *B. turbinata* are almost identical in shape.

The *B. ditrupæ* in my collection from Naples and Capri are biserial, while those from Trieste are 4-serial, and in these again the outer avicularia are larger than the inner.

A specimen from Rapallo, having been decalcified, does not admit of complete comparison.

Bugula calathus, *Norman*. (Pl. 2. figs. 4 & 10.)

Bugula calathus, *Norman, Q. J. Micro. Sc.* (n. s.) vol. viii. p. 218, pl. vi. figs. 3–8; *Hincks, Brit. Mar. Polyzoa*, p. 82, pl. xi. figs. 4–6; *id. Ann. & Mag. Nat. Hist.* ser. 5, vol. xvii. p. 260.

Bugula avicularia, forma flabellata, *Waters, Ann. & Mag. Nat. Hist.* ser. 5, vol. iii. p. 117.

It has been considered by Pergens and others that the Mediterranean form should be called *Bugula calathus*; and although I should not have been prepared myself to separate it from *B. flabellata*, yet in deference to the opinion of others I leave it as *B. calathus*, instead of considering it the Mediterranean form of *flabellata*. The cells, ovicells, and avicularia are smaller than those of *B. flabellata* from Roscoff; whereas Hincks says of the British *B. calathus* that these organs are on a larger scale than in *B. flabellata*. The mandible in *B. flabellata* is 0·16 mm. long, and in the Mediterranean *B. calathus* 0·12 mm. The character chiefly relied upon for the separation of the two species is the contrast in colour; but Vigelius ("Ontogenie der Marinen Bryozoen," Mitth. a. d. Zool. Stat. z. Neapel, vol. vi.

p. 505) points out that the colour varies considerably in the Gulf of Naples according to the time when they are taken.

The primary zoœcium has a central spine at the base of the area, and one on each side halfway up as well as three spines at each upper corner. The three lower spines are often reduced to mere protuberances. An "additional spine" on the margin of the aperture about halfway up occurs in many zoœcia of all ages; in fact I have found it more frequent than in *B. ditrupæ*, where it was first noticed by Hincks.

The number of spines is undoubtedly a character of great diagnostic value in the *Bugulæ*, but until every character has been compared we are likely to go astray sometimes.

SYNNOTUM AVICULARE, *Pieper*. (Pl. 1. figs. 6, 7.)

Gemellaria avicularis, *Pieper, Jahresb. d. Westfälischen Provinzial-Vereins*, vol. ix. p. 43, pl. ii. figs. 5–9.

Notamia avicularis, *Waters, "On the Use of the Avicularian Mandible" &c., Journ. R. Micro. Soc.* ser. 2, vol. v. p. 6 (name only).

Synnotum aviculare, *Hincks, Ann. & Mag. Nat. Hist.* ser. 5, vol. xvii. p. 257.

? Gemellaria egyptiaca, *Savigny* (name on plate), pl. xiii. fig. 4, *but* Loricaria egyptiaca, *Audouin, 'Description de l'Égypte'* (in text).

Mr. Hincks has given a full description, in which he allows that the structure of the zoarium is essentially the same as in *Notamia* (now *Epistomia*), and agrees with Pieper that it may perhaps be regarded "als Verbindungs-Glied zwischen *Gemellaria* und *Notamia*." For my own part I should not have removed it from *Epistomia* (*Notamia*), and still doubt whether a new genus is required, but, as that is not an important point, have put it under the genus proposed by Pieper and Hincks. There has been great confusion concerning the nomenclature of the genera *Gemellaria* and *Notamia*; and while recognizing the correctness of Gregory's remarks * on the use of the name *Gemellaria* †, I feel much

* "British Palæogene Bryozoa," Trans. Zool. Soc. vol. xiii. p. 227.

† In reference to the date of publication of Savigny's plates, on which the name "Gemellaire" first appeared, there seems a probability that they were placed in the hands of various naturalists before the text was published. I purchased a volume of plates from Friedländer, without text, but there was a manuscript list of plates and figures, headed 'Zoologie de l'Égypte: Iconographie des Échinodermes, des Polypes, et des Zoophytes; par Jules César de Savigny, 1806–1812." This may have been copied from an older list! The names of all the genera, whether established or new, appear at the foot of the plates in the French form.

hesitation in making a change, seeing that the two names have been used by Hincks, Busk, Smitt, Vigelius, Lorenz, Freese, Winther, Levinsen, and others.

As Hincks did not publish a figure, and as Pieper's paper is not very accessible, one is now given.

This is a very delicate species and may be easily overlooked. One specimen from Rapallo has the long tubular rooting-process given off from the back of the zoœcium near the middle. *Diploecium simplex*, Kirkpatrick, has similar rooting-fibres from the centre of an internode, but this is not mentioned in the description; and as some specimens of *Synnotum aviculare* have few or no radicals*, I would again call attention to the frequency in the attached Bryozoa of radicular disks being formed without a chitinous tube growing from them. This occurs in *Palmicellaria parallelata* and *Alysidium Lafontii*.

The first internode in a branch has one zoœcium. This is also the case in *Epistomia bursaria*; and in *Didymia simplex* similar internodes occur in the earlier branches, but not throughout the colony. *Calwellia bicornis*, however, has the first internode of a new branch double; whereas a specimen from Port Phillip sent to me, named †*Calwellia gracilis*, MacG., is *Synnotum aviculare*.

The shape of the colony, and the zoœcia, as well as the position of the radical, leaves no doubt in my mind that this is the *Gemellaria egyptiaca* of Savigny, and that the avicularia were overlooked, but this was often the case when their importance was less understood.

Loc. Trieste; Naples; Rapallo; Portland, Victoria (*MacG.*); Port Phillip; S. Africa, a small specimen submitted to me in Miss Jelly's collection.

Epistomia bursaria, *L.* (Pl. 2. figs. 8 & 9.)

Notamia bursaria, *Hincks, Brit. Mar. Polyzoa*, p. 100, pl. iv. figs. 1–5; which see for synonyms.

This, so far as I am aware, has not before been found in the Mediterranean, and I only obtained one specimen from Rapallo. The supporting stalk carries an avicularium just below the first

* See "Mediterranean and New Zealand Reteporæ," Linn. Soc. Journ., Zool. vol. xxv. p. 267.

† MacGillivray, "New or little-known Polyzoa," pt. ix., Trans. Roy. Soc. Vict. vol. xxii. p. (1).

internode, and this upper portion does not seem to have contained any polypide. It would thus seem that the upper part of the stem may be cut off as a barren internode, carrying a sessile avicularium identical in structure with those on the mature zoœcia.

The erect stem does not start direct from the creeping tube, but evidently there is a diaphragm, or rosette-plate, in the extended stolon by which stem and stolon are in connexion.

BEANIA MAGELLANICA, *Busk.* (Pl. 2. figs. 11–14.)

The small projections on the distal end of the zoœcium, described from my Naples specimens, are also seen in those from Rapallo. These Jullien did not find in the specimens from Cape Verd or from Tierra del Fuego, but my observation has been confirmed by others.

The mandible of *Beania magellanica* and *B. bilaminata*, Hincks, has a double "columella." This I have figured (Journ. Roy. Micro. Soc. ser. 2, vol. v. pl. xiv. fig. 4).

Ortman states that in the Japanese specimens the border of the avicularium is dentate, but this is not the case with those from the Mediterranean.

As the large figure, given by Jullien, does not correctly show the muscles of the avicularium, I have added figures showing that besides the large adductors there is a semicircular row of short muscles, which no doubt contracts the integument behind the mandible and thus helps in the slow opening of the beak. The "cellular body" of the avicularium, as elsewhere mentioned, occurs in a sheath, the equivalent of the sheath of the polypide.

The "eggs" described by Jullien occur one on each side of the zoœcium, in the same position as the ovarium, contain refractive cells, and are similar in structure to what I term the "median body" * in *Schizoporella sanguinea*. In my specimens of *Beania magellanica* they are usually globular, but sometimes become sausage-shaped.

The zoœcia are often nearly filled by the testes which seem to grow from the two sides, lower down than the ovarium. The remains of the polypide become encysted, forming brown bodies. The budding polypides originate from close to the connecting tubes, in fact sometimes seem to be almost within them.

* "Observations on Gland-like Bodies in the Bryozoa," Linn. Soc. Journ., Zool. vol. xxiv., 1892.

These connecting tubes have usually but one rosette septum, but occasionally there are two, with the parenchym threads attached to both and passing through the junction (see figs. 11 and 12.)

Loc. Adriatic, Naples, Marseilles, Rapallo, Riou and Podestà (*Marion*), Bonifacio; Straits of Magellan, New Zealand, Port Jackson, Portland (Victoria), Mauritius, Cape Verd Is., Kerguelen Island, Japan.

BEANIA MIRABILIS, *Johnst.* (Pl. 2. fig. 1.)

In the Rapallo specimens there are normally two radicals to each zoœcium, and this would seem to be generally the case.

The position of the septum a short distance from the parent zoœcium appears to be constant. There is no septum in the neighbourhood of the new zoœcium. The septal division takes place in the stolon very soon after its formation.

Although there is no "Kapsel," the position of the septum may be compared with that in the stolon of *Hypophorella expansa*, Ehlers; namely, immediately beyond each new zoœcium.

BEANIA HIRTISSIMA, *Heller*, var. ROBUSTA, *Hincks.*

Diachoris hirtissima, *H.*, form robusta, *Hincks, Ann. & Mag. Nat. Hist.* ser. 5, vol. viii. p. 74, pl. v. figs. 9, 9*a*; *Waters, Journ. Micro. Soc.* ser. 2, vol. v. pl. xiv. fig. 5 (mandible).

This form occurs fairly abundantly at Naples, Capri, and Rapallo. It often has the avicularium showing on the dorsal surface instead of in front. There is no definite radical as in *B. hirtissima* var. *typica*, but there are often numerous fibres on the dorsal surface, which in some cases look like spines, in others more resemble the rooting-fibres.

In a specimen from New Zealand the distal spines are rather smaller than in the Mediterranean specimens, but both these and the marginal spines correspond in structure and position. In the New Zealand specimen the ovicell is larger than in those from Naples, with the mandible nearly twice as wide and with the distal end round.

Hincks described this variety from Algiers.

BEANIA HIRTISSIMA, *Heller*, typica.

Diachoris hirtissimia, *Heller, Bry. Adriat. Meeres*, p. 94, pl. i. figs. 6, 7.

I have characteristic specimens from Rapallo. The usual armature may be taken as 7 stout spines round the oral aperture close

up to the border, and six others of the same size farther removed, making an irregular second row. On the lateral margins of the zoœcia there are about 10 delicate spines, directed inwards towards the median line, and 4–6 directed outwards. Dorsal surface with numerous spines, and sometimes, but not always, a radical tube starting from close to the proximal end. In *Beania magellanica* this tube is almost central. The *Chaunosia hirtissima* of Busk would seem to be the var. *cylindrica*, and I am not sure, therefore, which variety was dredged by the 'Challenger' at Cape Verd Islands.

Chlidonia Cordieri, *Aud.* (Pl. 1. figs. 8 & 9.)

Eucratea Cordieri, *Aud. in Savigny's 'Égypte,'* p. 74; *Waters, Bry. of the Bay of Naples, Ann. Mag. Nat. Hist.* ser. 5, vol. iii. p. 116, pl. xv. figs. 9, 11, pl. xxiii. fig. 12.

Cothurnicella dædala, *W. Thomson, Proc. Zool. Bot. Assoc. Dublin,* vol. i. p. 85, pl. viii. figs. 3–5, & *Nat. Hist. Rev.* vol. v. p. 146.

Chlidonia dædala, *MacGilliv. Zool. Vict.* dec. xi. p. 35, pl. cviii. fig. 2.

Chlidonia Cordieri, *Savigny's 'Égypte,'* pl. xiii. fig. 3 (*in text* Eucratea); *D'Orbigny, Paléont. Franç.* p. 40; *Busk, 'Challenger' Report,* p. 8, pl. xxviii. fig. 11; *Hincks, Ann. Mag. Nat. Hist.* ser. 5, vol. xvii. p. 258; *MacGillivray, Cat. Mar. Polyz. Vict.* p. 10.

The stalk, consisting of calcareous cylinders connected by corneous tubes, has a parenchym running through it, which in each cylinder sends out a branch to an external disk (see fig. 8). There are three other stalked genera, namely *Rhabdopleura*, *Kinetoskia*, and *Stirparia*, but in none of them, so far as can be judged from the descriptions, do the stalks resemble those of *Chlidonia*. A fuller knowledge of the earlier stages of these stalked species is much wanted, for of course these stalks are quite different from the radicals thrown out by many species of Bryozoa. In none of the species with stolons and stalks do we know the form of the primary zoœcium. The stalk of *Stirparia glabra* (see opposite) has two interior chitinous cords (woodcut fig. 3), which are formed by an internal thickening of the chitinous wall, and the structure of the stalk in no way resembles that of *Chlidonia*.

Rhabdozoum can scarcely be compared with the other stalked genera, as from the front of the zoarium a plain pedicular tube is given off, from which a fresh branch grows. In the stalked specimens of *Rhabdozoum* that I have examined many stalks grow from one stolon.

Epicaulidium has somewhat similar internodes.

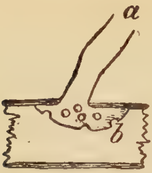
Busk in the 'Challenger' Report makes the zoœcium of *Chlidonia* bicamerate with no connexion between the chambers, but sections show that there is no division. A very considerable thickening of the shell in front (Pl. 1. fig. 9) contracts the zoœcial chamber, but nowhere does there seem to be a second chamber. At the distal end there is certainly a small portion cut off, into which the parenchym passes, through pores of communication, then reaching the next zoœcium after traversing the horny internode.

Alysidium parasiticum, Busk, is rooted by corneous tubes, which sometimes have calcareous nodes, from which the stalk of a colony grows.

Loc. Naples, Trieste, Rapallo, Algiers, Nice, Tunis, Egypt, Tyre, Calvados, Victoria (Australia), Cape York, New Zealand; Atlantic (*fide* Carus).

On the stalk of *Stirparia glabra* there are capsules looking like the gonophores of Hydrozoa. These were a great puzzle; and I was unable to elucidate them until Mr. Kirkpatrick afforded me the opportunity of examining the British Museum specimens of *Stirparia*. However, Hincks mentions (Ann. Mag. Nat. Hist. ser. 5, vol. xi. p. 105) the radical tubes and the way in which they pass from one internode to another; and these radicals in the 'Challenger' *S. glabra*, from Bahia, are just below the internode, though sometimes passing from one internode to another, forming a knot of chitinous tubes, much like those occurring in *Cellaria*. But in an unnamed species from Kurrachee there are similar structures, which sometimes become very wide or club-shaped at the end of a short or long stalk-like tube (woodcut fig. 1). In one piece they are abundant, and one joint has as many as 17 radical tubes, some of which form capsules. Though some are torn or burst, there seem no definite opening and no contained organs, but at the apex there is an accumulation of protoplasm, such as is constantly seen in the tips of growing radicals.

It is thus seen that the radicals occur in specimens from Bahia, West Australia, and Kurrachee, and that in those from the last two localities they may take the form of a capsule; but the object of this modification is not clear.



× 85 FIG. 2.

× 150 FIG. 3.

FIG. 1. × 15

Fig. 1. Stalk of *Stirparia* from Kurrachee, showing one branch and numerous radicals, some of which are club-shaped.

Fig. 2. Section of stalk (*b*) of *Stirparia glabra*, Hincks, from West Australia, showing origin of a radical (*a*).

Fig. 3. Transverse section through the stalk of *Stirparia glabra*, cutting through the chitinous cords formed by an internal thickening of the chitinous wall.

EXPLANATION OF THE PLATES.

PLATE 1.

Fig. 1. *Aetea recta*, Hincks; showing ovicells. ×25.

2, 3. Do.; ovicells. × 85.

4. Do. The ovarium fills up most of the lower portion of the zoœcium, and the tubular prolongation which is bent back carries an ovicell. × 85.

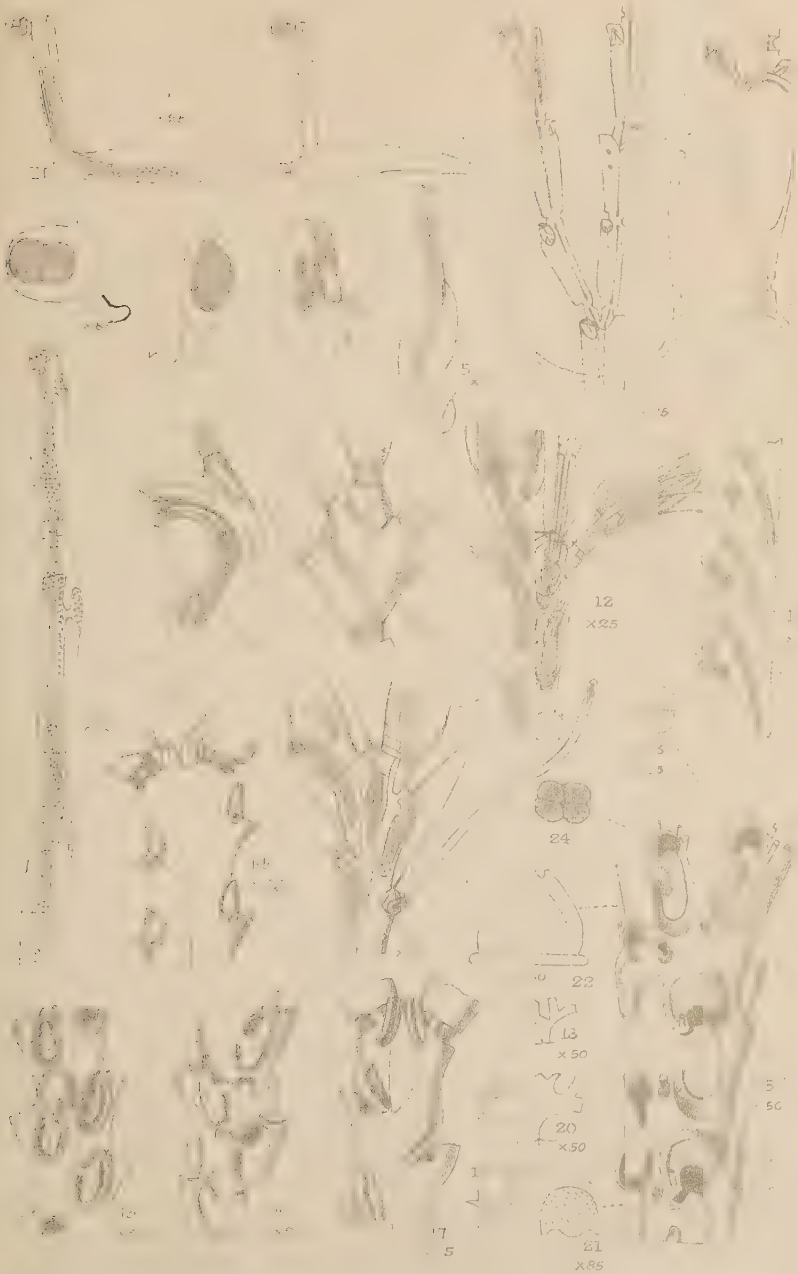
5. Do.; showing the position of the polypide in the zoœcium. × 85.

6. *Synnotum aviculare*, Pieper; showing the lateral sessile avicularia. × 25.

7. Do.; showing the large pedunculate avicularium. × 85.

8. *Chlidonia Cordieri*, Aud. Stalk showing disk, to which the parenchym is attached. × 25.

9. Do. Zoœcium, showing the position occupied by the polypide, and also the small separate chamber from which the next zoœcium starts. × 85.



...est, Ne... ...

...ED... ...RRA... AN... ...RYOZOA

West, Newman imp.

Fig. 10. *Menipea Buskii*, W. Thomson. Dorsal surface showing the two small chambers *a* and *b*, from which the next zoœcium starts. ×25.

11. *Scrupocellaria inermis*, Norman. Dorsal surface; transparent preparation showing the method of articulation, and the position of the polypide in the articulating joint. The vibracular chambers, and the chambers from which the radical starts are also shown.

12. Do. Anterior surface, showing the position of the polypide at the articulation.

13. *Caberea Darwinii*, Busk; Station 135, 'Challenger.' Lateral surface. ×25.

14. *Scrupocellaria Delilii*, Aud. Dorsal surface. × 25.

15. Do. Anterior surface. × 25.

16. *Scrupocellaria incurvata*, Waters. Anterior surface. × 25.

17. Do. Dorsal surface. × 25.

18, 19. *Scrupocellaria Bertholletii*, Aud. Fornices from one colony. ×25.

20. *Scrupocellaria reptans*, L. Fornix. × 50.

21. *Caberea Darwinii*, Busk. Operculum. × 85.

22. Do. Avicularian mandible. × 250.

23, 24. Do. Ova out of the ovicells. × 85.

25. Do. Anterior surface. × 25.

Plate 2.

Fig. 1. *Beania mirabilis*, Johnston; showing the two radical processes, and also the diaphragm in the stolon near to the zoœcium from which it has arisen. × 25.

2. *Bugula ditrupæ*, Busk. Primary zoœcium. × 85.

3. Do. The same, showing the commencement of the colony. × 25.

4. *Bugula calathus*, Norm. "Primary" and second zoœcium. × 25.

5. *Bugula plumosa*, Pallas. Young zoœcium from the extremity of a long basal process. ×85.

6. Do. Same colony. × 12.

7. Do. Process showing first and second zoœcium.

8. *Epistomia bursaria*, L. Stalk and lower part of colony. × 25.

9. Do. Origin of stalk from the creeping stolon. × 85.

10. *Bugula calathus*, Norman. "Primary" zoœcium. × 25.

11. *Beania magellanica*, Busk; showing position of egg-masses. × 25.

12. Do. Connecting-tube with two septa. × 150.

13. Do. Egg-mass. × 250.

14. Do. Avicularia. × 85.

15. *Bugula spicata*, Hincks. Mandible. × 250.

16. *Bugula ditrupæ*, Busk. Mandible. × 250.

Observations on the Holothurians of New Zealand; with Descriptions of four New Species, and an Appendix on the Development of the Wheels in *Chirodota*. By ARTHUR DENDY, D.Sc., F.L.S., Professor of Biology in the Canterbury College, University of New Zealand.

[Read 5th November, 1896.]

(PLATES 3–7.)

1. INTRODUCTORY REMARKS.

MY attention was first directed to the subject of this communication shortly after my arrival in New Zealand, by the receipt of a remarkable specimen collected on the New Brighton (Christchurch) beach by Mr. R. M. Laing, M.A. I shortly afterwards received a second specimen of the same species from Mr. J. P. Grossmann, M.A., of which I made a detailed anatomical examination. The species proved to be a new *Colochirus*, covered with overlapping scales, and is described in the context as *Colochirus ocnoides.*

Early in the course of this investigation, I was greatly struck with the inadequacy of our knowledge of the New Zealand Holothurians, and especially with the remarks to that effect made by Théel in his 'Challenger' Report.

I therefore determined to attempt a revision of the group, and proceeded to Wellington with a view to examining the type specimens in the Colonial Museum. Thanks to the kindness of Sir James Hector, I was enabled to do this, so far as the present condition of the specimens allowed. I found there specimens, apparently the original types, of "*Synapta uncinata*," "*Synapta inæqualis*," "*Molpadia coriacea*," "*Chirodota? alba*," "*Thyone brevidentis*," and "*Thyone longidentis*," described by Hutton in 1872 in his 'Catalogue of the Echinodermata of New Zealand.'

I unfortunately found these specimens in a very bad state of preservation, owing to the short-handedness of the Museum staff, but they were still of the greatest service in determining questions of synonymy.

Captain Hutton himself very kindly placed at my disposal type-slides of the spicules of his "*Molpadia coriacea*," "*Chirodota alba*," "*Thyone caudata*," and "*Holothuria mollis*," all marked "Wellington."

I also applied to Professor T. J. Parker for material from the

Dunedin Museum, and am greatly indebted to him for named specimens of "*Thyone caudata*," "*Echinocucumis alba*," and especially his own "*Chirodota dunedinensis*," as well as for a new species of *Psolus* collected at the Macquarie Islands.

Unfortunately the type specimens of Hutton's "*Cucumaria Thomsoni*," "*Labidodesmus turbinatus*," and "*Holothuria Robsoni*" had been sent from Dunedin to the Colonial and Indian Exhibition in London, and thence presumably to the British Museum; so that I am unable to add anything to our knowledge of these species, and can only hope that they will be re-examined by the Museum authorities.

I am also indebted both to Captain Hutton and Professor Parker for several additional specimens of that remarkable Holothurian *Caudina* (*Molpadia*) *coriacea*, and to Captain Hutton again for the loan of specimens of *Colochirus ocnoides*, n. sp., and *Cucumaria Huttoni*, n. sp., from the Canterbury Museum.

Mr. H. Farquhar, of Wellington, very kindly gave me another specimen of "*Echinocucumis alba*," dredged in Wellington Harbour, and allowed me to make use of a manuscript Catalogue of New Zealand Echinodermata compiled by himself.

While I was staying at Wellington, my friend Mr. H. B. Kirk took me to some of his favourite collecting-grounds in Cook Straits, where we secured living specimens of *Stichopus mollis*, Hutton sp., and *Colochirus calcarea*, n. sp. Mr. Kirk also sent me a further supply of these species to Christchurch.

To all these gentlemen I wish to express my very sincere thanks.

The only other Holothurians known from New Zealand are those collected by the 'Challenger' Expedition and described by Théel. I have of course been unable to examine the types of these, but the full descriptions and figures given in the 'Challenger' Report render this unnecessary. Indeed I ought also to express my indebtedness to the admirable monographic account of the group given in the 'Challenger' Report, as but for it I could not have completed this investigation, for I need hardly point out that in the absence of zoological libraries such a piece of work becomes almost impossible.

2. Summary of Results.

The majority of the already known species of New Zealand Holothurians have been re-examined, especially with regard to

the hitherto almost entirely unknown internal anatomy and spiculation, and the results are given in the body of this paper, illustrated by figures of the characteristic spicules and other parts.

Four new species are described and illustrated, viz., *Cucumaria Huttoni*, *Colochirus ocnoides*, *Colochirus calcarea*, and *Psolus macquariensis*.

The 'Challenger' specimens of *Chirodota australiana* are shown to be probably identical with *C. dunedinensis*, the sigmoid spicules of the latter having been hitherto unrecorded; so that it is very doubtful if the Australian species has been found in New Zealand waters at all, unless indeed the two be identical.

Echinocucumis alba, Hutton, is shown to be a *Colochirus*.

Thyone brevidentis, Hutton, is shown to be almost certainly a *Colochirus* also.

Thyone caudata, Hutton, and *Thyonidium rugosum*, Théel, are shown to be identical with *Thyone* (*Pentadactyla*) *longidentis*, Hutton.

Stichopus sordidus, Théel, is shown to be identical with *Holothuria mollis*, Hutton, which is really a *Stichopus*.

Allowing for these determinations in synonymy, the number of known species of New Zealand Holothurians now becomes seventeen, but four of these, viz., *Synapta inæqualis*, *Cucumaria* (?) *Thomsoni*, *Cucumaria* (?) *turbinata*, and *Holothuria Robsoni*, are still very imperfectly known and may prove to be synonymous; while two of them, viz., *Ankyroderma Marenzelleri* and *Holothuria lactea*, were obtained by the 'Challenger' in deep water, and perhaps ought scarcely to be included in the New Zealand fauna.

It is remarkable that no fewer than three of our New Zealand species, viz., *Cucumaria Huttoni*, *Colochirus alba*, and *Colochirus ocnoides*, are provided with overlapping dermal plates, a condition which elsewhere does not appear to be at all common in the group.

Théel has already pointed out that the genus *Colochirus* is especially characteristic of the Indian and Pacific Oceans, so that it is not surprising to find that no fewer than four of our species are referable thereto.

I have not thought it necessary to give figures of the general anatomy because no strikingly new anatomical facts have been discovered, and descriptions of the internal organs appear generally to be sufficient for systematic purposes.

Perhaps the most interesting anatomical result is that *Chirodota*

dunedinensis is shown to be unisexual, as opposed to the hermaphrodite condition supposed to be characteristic of the genus.

A little-known type of spicule is described in a species of *Stichopus* (figs. 83–87); and some apparently new facts concerning the structure and development of the wheels of *Chirodota* are given in the Appendix.

The arrangement of the genera is that followed in the 'Challenger' Report.

3. The New Zealand Species.

Synapta uncinata, *Hutton.*

1872. Synapta uncinata, *Hutton, Cat. Echinoderm. N. Z.* p. 16.

1886. Synapta uncinata, *Théel, 'Challenger' Holothurioidea*, p. 27.

The original description runs:—"Body curved, ? tapering behind, broadest at the mouth; tentacula thirteen, very short, merely tubercles, with two incurved hooks at the end of each.

"Pale reddish-brown.

"Length ·6; breadth at anterior end ·2.

"Dermal plates anchor-shaped; the flukes equal."

A small jar in the Wellington Museum, labelled "31. *Synapta uncinata*," contained what is evidently the type and only known specimen of this species. The specimen is merely the anterior end of the animal, about half-an-inch in length, bearing the crown of thirteen tentacles. The individual to which it belonged may have been of considerable size, probably at least four or five inches in length. The thirteen tentacles are of equal size and arranged in single series. In their present contracted state they are short and stumpy, and each bears four incurved digits at its extremity, the two inner ones being larger than the two outer. They are evidently the two larger digits to which Hutton refers under the name of "incurved hooks." Each tentacle also bears along each margin, and facing inwards, a double row of small projections which are indistinguishable from sucker-bearing tube-feet.

On cutting the specimen open, I found the madreporic ring and its appendages still in a fair state of preservation. There were nine long, straight, slender Polian vesicles and three madreporic canals. Of the latter, two were branched and slightly convoluted; the other much convoluted, but apparently not branched. The madreporic canals were situate dorsally, on the same side as the mesentery. The longitudinal muscles were very strongly developed, and there were no retractors.

Although I examined preparations of the integument, both simply cleared with absolute alcohol and oil of cloves and after boiling with caustic potash (2 per cent. solution), I could find no spicules, nor could I find any pharyngeal skeleton.

Possibly the spirit in which the specimen has lain for more than twenty years may have contained some acid which has effectually removed all calcareous deposits.

SYNAPTA INÆQUALIS, *Hutton.*

1872. Synapta inæqualis, *Hutton, Cat. Echinoderm. N. Z.* p. 17.

1886. Synapta inæqualis, *Théel, 'Challenger' Holothurioidea*, p. 32.

The original description runs:—"Conical; inflated anteriorly and tapering behind; soft, minutely papillose; tentacles none?

"Brownish grey.

"Length 1·0; breadth at the anterior end ·33.

"Dermal plates anchor-shaped, with one fluke much longer than the other."

The type specimen in the Wellington Museum is in a perfectly useless condition. It was nearly dry when I first saw it and has apparently at some time been completely desiccated, so that it now resembles a small fragment of brown, shrivelled leather. As in the type of *S. uncinata*, the spicules have apparently all been dissolved out.

CHIRODOTA DUNEDINENSIS, *Parker.* (Pl. 3. figs. 1–8.)

1881. Chirodota dunedinensis, *Parker, Trans. N. Z. Inst.* vol. xiii. p. 418.

1886. Chirodota australiana, *Théel, 'Challenger' Holothurioidea*, p. 16.

1886. Chirodota dunedinensis, *Théel, 'Challenger' Holothurioidea*, p. 34.

The original description of the species runs:—"Tentacles ten, each with about ten processes, which increase in size progressively from the proximal to the distal end. Integument quite smooth, there being no tentacles or papillæ. Colour yellowish (owing to the bright yellow viscera shining through the translucent skin) with small crimson spots which disappear in spirit; tentacles whitish, with dark spots on the inner side at the base; these spots are unaffected by spirit. Length, in the extended condition, about 4 cm. Otago harbour: littoral."

This is supplemented by the following generic diagnosis:—"Worm-like; calcareous spicules in the form of wheels imbedded

in the skin ; tentacles shield-shaped, produced at the edges into finger-like processes (Tentacula peltato-digitata)."

Professor Parker has very kindly sent me six specimens of this beautiful little Holothurian, three preserved after treatment with osmic acid and three after treatment with picric. Although it is ten or twelve years since they were bottled, the specimens are in an excellent state of preservation, especially those treated with picric acid. I am thus able to add the following particulars to the above description.

The spicules (which have not been perceptibly injured by the method of preservation) are of two kinds :—(1) Wheels (figs. 1–6), about 0·16 mm. in diameter, and each with six spokes (*vide* Appendix). (2) Contorted sigmoid spicules (fig. 7), resembling the siliceous spicules known as "contort sigmata" in sponges; measuring about 0·11 mm. from bend to bend. Both kinds of spicule are abundant and both are loosely and irregularly scattered through the interambulacral integument, not aggregated in papillæ ; but whereas the sigmata occur abundantly in all the interambulacra, the wheels appear to be entirely absent from the two interambulacra of the ventral surface.

There is a pharyngeal skeleton in the form of a slender calcareous ring of ten simple pieces, of which the ends touch (fig. 8).

The integument is thin and translucent, but the five longitudinal bands of muscle are well developed. There are, of course, no retractor muscles.

The alimentary canal is not thrown into loops but runs straight from mouth to anus, and is slightly convoluted by the contraction of the body.

There is a single elongated, slender Polian vesicle, placed ventrally ; and what appears to be the madreporic canal is very small and situate dorsally.

The sexes are distinct, and the females may be readily distinguished by the relatively large eggs in the ovary, which give that organ a coarsely granular appearance very different from that of the smooth-looking testis. The reproductive organs have the same form and relations in both sexes, consisting of a few long slender tubes hanging down from the end of the short genital duct, which lies dorsally at the anterior end of the body. The longer tubes extend back nearly to the hinder end of the body.

The condition of the reproductive organs is especially inter-

esting, because the genus *Chirodota* is usually considered to be characteristically hermaphrodite; and this is, I believe, the first species known to depart from the typical condition in this respect.

The species is evidently very closely related to *C. australiana*, Stimpson *. Théel, however, being unaware of the existence of sigmoid spicules in *C. dunedinensis*, placed it in a different section of the genus. As a matter of fact the Australian species seems to be distinguished by little if anything more than the aggregation of the spicules into two kinds of papillæ. A comparison of the two may even show them to be identical, but I do not think this very likely.

Théel observes that in the 'Challenger' specimens identified by him with *C. australiana*, "the wheels and sigmoid bodies seem to be present all over the body," and that the aggregation of the spicules into papillæ was not distinct. These specimens at any rate are probably identical with the Dunedin species. The record of locality in the 'Challenger' Report seems to be somewhat doubtful, viz. "*Habitat.* Port William (New Zealand, Falkland Islands ?); depth 5–10 fathoms; two specimens."

Ankyroderma Marenzelleri, *Théel.*

Ankyroderma Marenzelleri, *Théel, 'Challenger' Holothurioidea*, p. 41, pl. iii. fig. 1.

This appears to be a deep-water species, and only a single incomplete specimen was obtained by the 'Challenger,' from a depth of 700 fathoms (Station 169). It has not since been met with.

Caudina coriacea, *Hutton.* (Pl. 3. figs. 9–18.)

1872. Molpadia coriacea, *Hutton, Cat. N. Z. Echinoderm.* p. 17.

1879. Caudina (?), Echinosoma (?), *Hutton, Trans. N. Z. Inst.* vol. xi. p. 307.

1883. Caudina meridionalis, *Bell, Proc. Zool. Soc. Lond.* p. 58, pl. xv. fig. 1.

1886. Caudina coriacea, *Théel, 'Challenger' Holothurioidea*, pp. 47, 54, pl. iii. fig. 4.

The original description runs as follows:—"Body cylindrical, tapering rather suddenly into an attenuated and tapering tail, which is half the length of the body; skin rough, coriaceous; body transversely wrinkled; anterior end smooth; mouth with from ten to twenty short, simple papillæ; teeth five, long, bifid; longitudinal muscles with a deep central groove."

* *Vide* Théel, *loc. cit.* p. 16 &c.

"Pale brown.

"Length 4·0; breadth ·65."

This description is preceded by the following diagnosis of the genus *Molpadia* :—" Body attenuated posteriorly ; tentacula simple, short, cylindrical."

I found in the Wellington Museum a single specimen in a jar labelled "34. Molpadia coriacea," which is doubtless one of the specimens examined by Hutton, though as it had not been cut open it can hardly be the one from which the above description was taken. The specimen was in a very bad state of preservation, having evidently been desiccated ; in fact it was nearly dry when I first saw it. The spicules, however, were still present.

I have also received from Captain Hutton a type-slide of the spicules of this species, from Wellington.

I have also had for examination a fine specimen from Akaroa, belonging to the Canterbury Museum ; three *fresh* specimens cast up on the shore at Oamaru, from Captain Hutton ; and three spirit-preserved specimens from the same locality from Professor Parker. I have also seen a specimen cast up on the New Brighton beach ; so that the species would appear to be not uncommon on the East coast of New Zealand.

The original description was apparently based on a shrivelled specimen, and will be seen to require considerable modification. The 'Challenger' specimens were fragmentary, and the specimens described by Bell also seem to have been in a very unsatisfactory state. Théel states that he saw two specimens presented by Hutton to the State Museum of Stockholm, but he was evidently unable to make a complete examination of them. Under these circumstances the following particulars as to this very remarkable-looking Holothurian may be of interest.

The animal consists of an inflated, subcylindrical or ovoid body, broadly rounded in front and contracting suddenly behind to form the stout cylindrical "tail," which tapers gradually to the terminal anus. None of the specimens examined by me show any definite anal papillæ or teeth, as described by Théel for the 'Challenger' specimens. In the largest example which I have seen, the body and tail are each somewhat over 3 inches in length, the body about $1\frac{1}{4}$ inches in diameter in the middle, and the tail about $\frac{1}{4}$ inch in diameter in the middle.

The tentacles are fifteen in number, short and stumpy, each with four conical digits, two large and two small. They are

evidently the contracted tentacles which Hutton describes as "papillæ" in the neighbourhood of the mouth. In fresh specimens the body is of a dull purple colour, and the tail greyish yellow. The tentacles are orange, sometimes streaked longitudinally with pink. The body-cavity is filled with a large quantity of thin, reddish-brown liquid, resembling blood, to the presence of which the dull purple colour of the animal is largely due. The integument in fresh specimens is smooth and subglabrous all over, transversely wrinkled only at the root of the tail. It is thin and soft in the region of the body, though tough. It appears firmer in the tail because of the absence of any large, fluid-containing body-cavity therein.

The alimentary canal appears to be quite typical. It consists in the swollen "body" of three limbs, descending, ascending and, descending, forming the usual S-shaped loop, the last limb ending in the long, slender rectum, which occupies the whole of the tail and is attached to the body-wall by radial muscle-fibres. The two respiratory trees, attached to the commencement of the rectum, are large and very copiously branched.

The longitudinal muscles are powerfully developed, each consisting of two distinct bands with a deep groove between them. There are no properly developed retractor muscles, but these are probably represented by certain small slips of muscle which arise one from each half of each longitudinal muscle near its anterior end, and unite together in pairs to become attached to the radial plates of the calcareous ring.

The ambulacral ring has a single, sausage-shaped Polian vesicle, placed ventrally, and a single small madreporic canal, placed dorsally close to the genital duct. There are fifteen elongated tentacular ampullæ.

The sexes are distinct. The reproductive organs are bulky and consist of a great number of copiously branched, slender, moniliform tubes, attached near the anterior end of the body to the single short dorsal genital canal.

The pharyngeal skeleton (Pl. 3. fig. 18) consists of a complete calcareous ring of ten pieces. The five radials are rather large, and each ends posteriorly in a bifid prolongation. The interradials are small and simple, wedged in between the anterior ends of the radials. The anterior margin of the ring is provided with fifteen small sharp teeth, two belonging to each radial and one to each interradial.

The typical spicules (figs. 9–11) are described by Théel as "wheel- or cup-shaped deposits," and his figures leave no doubt as to their identity with those examined by me. I should prefer to describe them, however, as rings, which enclose a cross on the one side and a square on the other. The margin is undulating, curving in at eight points, where the cross and square are attached. The diameter of the ring is about 0·055 mm. These spicules are very abundantly scattered through the integument, forming an almost continuous crust.

As Théel has already pointed out, the spicules around the anus differ from those elsewhere, being irregularly branched or reticulate (Pl. 3. figs. 12–14). The tentacles contain only a few small reticulate plates lying near their bases.

This Holothurian is very remarkable for the brownish-red cœlomic fluid, which bears many points of resemblance to human blood. Under the microscope it is seen to consist of a colourless liquid in which numerous corpuscles float. The most conspicuous of these are spherical bodies (Pl. 3. fig. 15) of a brownish-yellow colour, and about a quarter as large again as human red blood-corpuscles. These are extremely numerous, and sometimes appear polygonal from mutual pressure (Pl. 3. fig. 15 *a*). They are mostly of about the same size, though some are a good deal smaller than the majority. Each contains, as a rule, one or a few highly refractive particles. A 5 per cent. solution of common salt causes the cell-contour to become wrinkled, but they never appear flattened like human red corpuscles.

Colourless corpuscles also occur in the cœlomic fluid; these appear to be of two kinds, some being only slightly smaller than the brown corpuscles and coarsely granular, while others are only of about half the diameter of the brown corpuscles, and finely granular. The cœlomic fluid does not coagulate on exposure to the air, but does so in alcohol.

The above observations were made on fresh specimens which had been out of the water for some little time.

The only kindred observations known to me are those of Howell, who describes* hæmoglobin-bearing corpuscles in the water-vascular and perivisceral fluids of *Thyonella gemmata*. Howell has also referred to the existence in this species of two kinds of colourless corpuscles; and the structural differences which

* Howell, W. H. Studies from the Biol. Lab. of Johns Hopkins Univ., Baltimore, vol. iii. p. 284.

I have observed in these in *Caudina* are suggestive of those discovered and more fully investigated by Hardy * in the Crustacea.

CUCUMARIA HUTTONI, n. sp. (Pl. **3.** figs. 19, 20.)

Body cucumiform, bluntly rounded in front, more tapering behind; posterior extremity slightly turned up dorsalwards. Integument smooth, but hard and thick, with minutely but distinctly scaly appearance, owing to the presence of overlapping calcareous plates, which are distinctly visible to the naked eye. No distinct teeth or papillæ around mouth or anus. Length of body a little more than 3 inches, diameter in the middle about two-thirds of an inch.

Tentacles copiously branched, dendriform, ten in number. The mid-ventral tentacle is longer, and that on each side of it shorter, than any of the others: the mid-dorsal is also perhaps rather shorter than the lateral tentacles, but all are well-developed.

The body when fresh is of a pale greyish-yellow colour. The tentacles are abundantly speckled with brown.

The ambulacral appendages are very feebly developed. Three irregular, multiple, but rather scanty rows of small pedicels (? any fully developed tube-feet) are visible on the ventral ambulacra, in the middle part of the body. None are visible on the dorsal surface. Dissection failed to reveal the presence of any ampullæ.

The five longitudinal muscles are undivided and powerfully developed. The retractors of the pharynx are remarkably strong, and spring from the corresponding longitudinal muscles at about one-third of the distance from the anterior to the posterior extremity of the contracted animal.

The pharynx (Pl. **3.** fig. 19) is very large and consists of two distinct parts. The anterior part is about half an inch in length, eversible, muscular and soft-walled. The posterior part is about an inch in length and is supported by the very strongly developed calcareous ring, to the radial pieces of which are attached the retractor muscles. The tentacles are attached at the junction of the anterior and posterior portions of the pharynx, a little in front of the retractor muscles. In the retracted state they point straight backwards, and are thus lodged in the posterior part of the pharynx, which they completely fill.

The calcareous ring (Pl. **3.** fig. 19) is very complex, and consists of ten compound pieces. The radial pieces are rather narrow, but

* HARDY, W. B. Journ. of Physiol. vol. xiii. p. 165.

they are prolonged backwards each into a pair of long slender many-jointed processes, the hinder extremities of which curl inwards at the bottom of the pharynx. These bifurcate prolongations are about an inch in length. The interradials are of about the same width as the radials in front, and are continued backwards between the bifurcate processes of the latter, for about three quarters of an inch, each in the form of a long flat rod made up of many joints. Owing to their much greater width, the backward prolongations of the interradials are much more conspicuous than those of the radials.

The entire ring closely resembles that of *Cucumaria conjungens*, as figured by Semper*; but in our species the interradials are prolonged much farther backwards, and the radials and interradials are separated by considerable intervals, instead of touching one another as in Semper's figure. This last feature is, however, probably dependent upon whether or not the pharynx is distended by the enclosed tentacles, as it is in our specimen.

There is a single dorsal madreporic canal running forwards for a short distance along the pharynx by the side of the genital duct. There are two Polian vesicles, situate ventrally, and remarkable for their great length and slenderness (fig. 19). Each is rather more than two inches long, so that when pulled out they reach backwards from their attachment at the hinder end of the pharynx to beyond the hinder end of the body.

Following immediately on the pharynx, the alimentary canal is for a short distance thick-walled and tubular. The thin-walled narrow intestine is very long indeed, and very greatly convoluted, the posterior portion, for some distance before the rectum, being twisted into a close spiral. The rectum is about an inch long, and attached to the body-wall by numerous radial muscles. The respiratory trees are strongly developed, copiously branched, with four main branches, one branch lying in each interambulacrum except the mid-dorsal.

The single specimen is a female; and the ovaries consist of two remarkably small bunches of short, slender tubes, attached right and left to the dorsal mesentery a little in front of the middle of the body. The single oviduct runs up along the dorsal mesentery as usual.

The spicules are flat reticulate scales or plates (Pl. 3. fig. 20), of

* 'Reisen im Archipel der Philippinen—Holothurien,' pl. xiv. fig. 4.

more or less oval shape, very abundant, large and small, measuring up to about 0·92 mm. by 0·77 mm. in the two diameters.

The specimen was found at Oamaru, and is the property of the Canterbury Museum.

Cucumaria (?) Thomsoni, *Hutton.*

1879. Cucumaria Thomsoni, *Hutton, Trans. N. Z. Inst.* vol. xi. p. 307.

1886. Cucumaria Thomsoni, *Théel, 'Challenger' Holothurioidea,* p. 116.

The original description runs as follows:—"Body fusiform, scarcely subpentagonal. Skin rough, wrinkled. Ambulacra with the tubercles densely crowded in about 5 or 6 rows. No feet on the interambulacral areas. Tentacles — ?

"Rich brown, the white tips to the feet giving the ambulacral areas a spotted appearance. Length $1\frac{3}{4}$ inches.

"Stewart Island.—Presented to the Museum by G. M. Thomson, Esq., after whom I name it. A single specimen in spirit."

This is all the information we have concerning the species, Théel simply mentioning it.

Professor Parker, who is now in charge of the Dunedin Museum, informs me that the type specimen was sent to the Colonial and Indian Exhibition in London, and thence to the British Museum, where it should now be, so that we must look in that direction for more light on the subject.

Cucumaria (?) turbinata, *Hutton.*

1879. Labidodesmus turbinatus, *Hutton, Trans. N. Z. Inst.* vol. xi. p. 307.

1886. ? Cucumaria turbinata, *Théel, 'Challenger' Holothurioidea,* p. 117.

The original description runs as follows:—"Body rounded, suddenly contracted posteriorly into a short-pointed tail, and anteriorly into a rather long, cylindrical neck; skin smooth, slightly transversely wrinkled; the two dorsal ambulacra with two rows each of rather distant feet; the three ventral ambulacra either like the dorsal or with more crowded feet in several rows. Tentacles — ?

"Body white, covered with a brown epidermis, which easily peels off, except round the ambulacral feet. Length $2\frac{1}{2}$ or 3 inches.

"Stewart Island.—Presented to the Museum by G. M. Thomson, Esq. Two specimens in spirits."

In this case again, Professor Parker informs me that the type

or types were sent to the Colonial and Indian Exhibition, and thence to the British Museum.

Colochirus alba, *Hutton*, sp. (Pl. 4. figs. 21–32.)

1872. Chirodota (?) alba, *Hutton, Cat. Echinoderm. N. Z.* p. 17.

1879. Echinocucumis alba, *Hutton, Trans. N. Z. Inst.* vol. xi. p. 307.

1886. ? Echinocucumis alba, *Théel, 'Challenger' Holothurioidea*, p. 119.

The original description runs as follows :—" Cylindrical, tapering behind; skin reticulated, and with longish papillæ on the back and sides; tentacula ten, large, branched and plumose.

" White; skin translucent; tentacles brownish white, spotted with violet on the inside near the base.

" Length 1 inch.

" Wellington Harbour (*H. Travers*)."

To this was added in 1879 the following :—" The receipt of another specimen of the *Chirodota* (?) *alba* of my Catalogue has enabled me to dissect it, and I find that it has five well-marked ambulacra, and should be placed in the genus *Echinocucumis*."

Théel observes that the species certainly does not belong to the genus *Echinocucumis*, and I find that it is really a *Colochirus*.

My own observations have been based upon :—(*a*) Two specimens from the Wellington Museum, in the same bottle, labelled " 33. *Chirodota ? alba*. Wellington Harbour." (One of these is probably Hutton's type.) (*b*) One specimen from the Dunedin Museum, labelled " *Echinocucumis alba*," and probably the specimen dissected by Hutton. (*c*) One specimen dredged in Wellington Harbour (12 fathoms, mud), and given to me by Mr. H. Farquhar, who had already identified it with Hutton's species.

The external appearance is very characteristic. The body, which is only about an inch in length, is bluntly rounded in front and tapers rather suddenly behind to a slender tail, which occupies about $\frac{1}{4}$ to $\frac{1}{3}$ of the total length of the animal. In three of the specimens the posterior half or more of the body is strongly bent dorsalwards, the middle of the body being somewhat swollen or bellied. I counted the tentacles in the larger of the Wellington Museum specimens, in which they were well extended, and found them to be dendriform, ten in number, with the two ventral very much smaller than the remainder.

Five ambulacral bands of rather conspicuous tube-feet (or

papillæ) extend from end to end of the body, being in approximately single series in the anterior and posterior portions, but more numerous in the middle, especially on the ventral surface, where there are also a few scattered on the interambulacra. Dissection revealed ampullæ only on the ventral side, in the middle part of the body.

The entire body is covered with overlapping calcareous scales, which give rise to the reticulate appearance of the skin observed by Hutton.

The anus is surrounded by a slight fringe of slender spicules.

The internal anatomy agrees very closely with that of *Colochirus ocnoides*, described below. There are two genital bundles, right and left, attached to the dorsal mesentery a little in front of the middle of the body. The Polian vesicle is single, dorsal, much inflated, lying to the left of the single dorsal madreporic canal. The respiratory trees are, as usual, attached to the anterior end of a long rectum, and the alimentary canal resembles that of *C. ocnoides*.

The calcareous ring is composed of ten Y-shaped pieces, with their forks directed backwards (Pl. 4. fig. 32). The radial pieces are much longer and project much further backwards than the interradials, so that the ends of the limbs of the interradials articulate with about the middle of the stems of the radials, which widen out somewhat at this point. The notch between the two limbs of the radials is also much smaller than in the interradials.

The most abundant spicules are the large and small reticulate plates or scales (Pl. 4. figs. 21–24), measuring up to about 1 mm. in diameter. In addition to these there are small, deep reticulate cups (Pl. 4. figs. 27–31), the margins of which are beset with a variable number of very conspicuous, rather slender, short projections. These cups, with their crown-like margins, are highly characteristic; they measure about 0·02 mm. across the margin, and about the same in depth. Perforated rods (figs. 25, 26) also occur in boiled-out preparations. They doubtless belong to the tube-feet.

Colochirus ocnoides, n. sp. (Pl. 4. figs. 33–43.)

Body cucumiform, cylindrical, with the posterior third or thereabouts strongly turned up dorsalwards and tapering to the anus. Anterior end much more bluntly rounded (when the

tentacles are retracted) than the posterior. Tentacles ten, tufted with short branches; the two ventral much smaller than the eight others.

Integument hard, covered with a close armour of imbricating scales. In the anterior and posterior portions of the body the scales overlap very regularly, the free edges pointing towards the extremity in each case. In the middle third the arrangement is less regular. The colour of the living animal is pink, and the colouring-matter appears to be located in the central portion of each scale. The oral and anal openings are guarded by a few irregular nodules.

The fully developed tube-feet appear to be confined to the middle third of the ventral surface of the body. They are very numerous and arranged in three crowded ambulacral bands. They have sucking-disks and ampullæ. Small papillæ are irregularly scattered over the dorsal surface, but chiefly on the ambulacral areas. Both tube-feet and papillæ die away towards the extremities, leaving the terminal portions of the body smooth but scaly. Both are far more numerous in the larger specimens.

The internal anatomy is typical. The five retractor muscles are well developed. The alimentary canal is very long and much convoluted in the middle part of its length, but still showing the usual arrangement in descending and ascending loops. The rectum is long, its actual dimensions varying with the state of contraction of the animal. The two respiratory trees are well developed and copiously branched, and extend forwards to the anterior end of the body. The genital organs consist of two voluminous tufts of slender cæca, situated in the middle third of the body, from which the genital duct runs forward dorsally along the mesentery to open close to the crown of tentacles (if not actually between two of them). There is a single Polian vesicle, attached to the ambulacral ring a little to the left of the mid-dorsal line, and a single madreporic canal attached dorsally (Pl. 4. fig. 33). The calcareous ring (Pl. 4. fig. 34) consists of ten **Y**-shaped pieces with their forks directed posteriorly. (In the radial pieces, to which the retractor muscles are attached, the single arm of the **Y** appears to be jointed on to the fork, but this is probably due to accidental fracture, caused by the excessive contraction of the muscles.) The radials and interradials are more nearly equal and similar than in *C. alba*.

The principal spicules are large and small, flat, reticulate

plates or scales (Pl. 4. figs. 35, 36), measuring up to about 1 mm. in diameter, and varying from oval to roundedly triangular in outline. In addition to these, there are small reticulate cups (Pl. 4. figs. 41–43), of the same fundamental form as in *C. alba*, but much larger and with the marginal projections represented merely by blunt warts. These cups measure about 0·054 mm. in diameter. Perforated rods (Pl. 4. figs. 37–40) occur.

The type specimen, from which the anatomical details were taken, measured about 53 mm. in length (exclusive of tentacles). Another specimen from the same locality (New Brighton) was of about the same size, but the tail portion was longer and narrower, apparently less contracted. Two more specimens, belonging to the Christchurch Museum, and of unknown locality, were respectively rather more and rather less than twice as long as the type, and thick in proportion.

One of the two larger specimens was also dissected and exhibited a peculiar abnormality in the tentacles, two dorsal being the smallest instead of the two ventral, which latter were well developed. The left dorsal retractor muscle was also found to be disconnected from the calcareous ring, so that its anterior end projected freely into the body-cavity. It looked as though it had been ruptured and the ruptured end had healed up. Possibly the degeneration of the dorsal tentacles is to be connected with the injury to this muscle. All the tentacles, however, were completely retracted.

It is not easy to convey in writing an adequate idea of the distinction between this species and the preceding. Both species are remarkable for their scaly armature. It is very interesting to find in two closely allied species from such near localities a slight difference in external characters accompanied by a slight but well-marked difference in spiculation.

Colochirus calcarea, n. sp. (Pl. 5. figs. 44–53.)

Animal minute. Body short, sausage-shaped, bluntly rounded at both ends and without dorsal flexure. Colour chalky white in life and in spirit. Tentacles dendriform, ten in number, the two ventral much smaller than the eight others; pale yellow in colour. Tube-feet in almost or quite simple series on the three ventral ambulacra. Papillæ on the dorsal surface, chiefly in two rows, sparse, moveable and retractile, each sometimes

with a pink tip. Anus surrounded by five teeth, each overhung (in life) by a slender cylindrical process *.

The largest specimen which I have seen measured, after preservation in spirit, about half an inch long by rather less than $\frac{3}{16}$ inch in greatest diameter.

In spirit specimens the tube-feet and papillæ appear to be very irregularly arranged, and no distinct teeth are visible around the mouth or anus.

The integument is thick, friable and chalky white, owing to the very numerous minute spicules which it contains.

The pharynx is provided with a slender calcareous ring of ten simple triradiate pieces, each with the odd ray pointing forwards (fig. 53). The radial pieces are rather larger than the interradials, and differ from them in being deeply notched posteriorly between the paired arms and in having the apex of the odd arm slightly bifid.

Following on the pharynx the short slender œsophagus passes directly into the wide intestine, the first part of which seems to have thicker walls than the remainder, but does not appear to be muscular. The intestine is rather wide throughout, looped in descending, ascending, and descending portions as usual, but not convoluted. The rectum is very short, the respiratory trees springing from close to the anus. The respiratory trees are short, digitate, with very short wide branches, very short even in proportion to the size of the body.

The reproductive organs consist of two small bunches of short cæca, placed one on each side of the dorsal mesentery rather far forward, just behind the œsophagus.

Retractor muscles as usual, but rather long and slender, springing from about the middle of the body.

Madreporic canal single and dorsal. Polian vesicle single, rather short, inflated, situated on the left side.

The most abundant spicules are small, oval, reticulate plates or buttons, each with four perforations, and studded on both surfaces with rounded, pearl-like knots, which give them a highly characteristic appearance (Pl. 5. figs. 44–47). These spicules measure about 0·062 mm. in longer diameter. There are typically fourteen knobs on each side, arranged as shown in fig. 47, but often

* I could not make certain whether or not similar processes occur also between the teeth. The processes look like ambulacral appendages.

one or two more or less, as in figs. 44, 45. There are also much smaller spicules (Pl. 5. figs. 48, 49) of similar general form, but concave on one side and with the knobs very small and irregularly scattered. These doubtless represent the cups of the other species of *Colochirus*; they measure about 0·029 mm. in longer diameter. Curved perforated rods (Pl. 5. figs. 50–52) are also abundant, especially at the bases of the tentacles and in the tube-feet. The tube-feet and papillæ are also provided with beautiful reticulate end-plates.

This interesting little Holothurian occurs not uncommonly on seaweed in Cook Straits, near Wellington, where it may be collected at low tide.

Colochirus brevidentis, *Hutton*, sp. (Pl. 5. figs. 54–61.)

1872. Thyone brevidentis, *Hutton, Cat. Echinoderm. N. Z.* p. 16.

1886. Thyone brevidentis, *Théel, 'Challenger' Holothurioidea*, p. 141.

The original description runs as follows:—"Cylindrical, rather flatter below, and rounded at both ends; papillate all over with suckers, those on the back larger and farther apart; tentacula ten, very short, of unequal length, triangular, frondose; teeth very short; longitudinal muscles narrow, attached to the dental apparatus.

"Brown; tentacles pink, with yellowish tips.

"Rather more than an inch in length."

Théel merely mentions the species; and the only specimen which I have seen is one belonging to the Wellington Museum, doubtless Hutton's type. Unfortunately it is in a very bad state of preservation. The tentacles and the whole of the viscera had been removed, leaving nothing but the integument, in the form of a dry and empty shell, shaped like a short, thick sausage.

The integument is thick and hard, owing to the very abundant spicules, and it is not corrugated. The smaller "suckers" observed by Hutton are doubtless tube-feet; they occur thickly and irregularly scattered over the ventral surface, except at the anterior and posterior ends. The larger papillæ, perhaps twice the size of the retracted tube-feet, are abundantly and pretty uniformly scattered over the remainder of the body; they appear to have retractile apices, and both tube-feet and papillæ are provided with well-developed reticulate end-plates.

The spicules are very numerous, forming a dense crust in the integument. The most abundant and characteristic are the

knobbed reticulate plates or buttons (Pl. 5. figs. 54–57), distinguished from those of *C. calcarea* by their somewhat larger size and less regular shape, measuring about 0·09 mm. in longer diameter. The characteristic reticulate cups of the genus are represented by small perforated plates beset with minute knobs. Some of these are closely similar to the cups of *C. calcarea*; some are almost, if not quite, flat and of irregular shape (Pl. 5. figs. 58–60); they are very numerous and vary a good deal in size. In the integument of the dorsal surface large reticulate nodules are also abundant; these are of rounded or oval form, and up to 0·5 mm. in longer diameter. Curved perforated rods (Pl. 5. fig. 61) and reticulate end-plates also occur.

Thus the spiculation makes a near approach to that of my *Colochirus calcarea*, but differs especially in the presence of the large nodules.

The arrangement of the ambulacral appendages and the spiculation leave no doubt in my mind that the species is really a *Colochirus*. The shortness of the "teeth," referred to by Hutton, and the unequal length of the tentacles also favour this view. It seems to be nearly related to *C. calcarea*, but differs from that species in its much larger size, in the much more numerous and more prominent papillæ, and in the spiculation as already pointed out.

PSOLUS MACQUARIENSIS, n. sp. (Pl. 7. figs. 70–72.)

Body in spirit slug-like, somewhat flattened ventrally to form a creeping sole, which extends from end to end and is not sharply defined. Broadly rounded in front and behind, about $\frac{7}{8}$ inch long and $\frac{1}{3}$ inch broad in the middle. Integument soft and smooth, but corrugated, chiefly transversely. Mouth anterior; anus at posterior end but slightly dorsal. There are three sharply defined ventral ambulacra, each with two or three rows of irregularly alternating tube-feet, possibly forming a single series when the body is extended. The remainder of the integument is quite devoid of ambulacral appendages. Tentacles ten, bushily branched and of about equal size.

Pharynx subglobular, thin-walled, swollen out with the indrawn tentacles. No complete calcareous ring, the pharyngeal skeleton being reduced to a few white patches composed of aggregations of granules. The retractor muscles, however, are well developed. Œsophagus short, marked off by a sharp

constriction from the globular, thick-walled stomach, which is followed by a long and rather wide thin-walled intestine. Rectum very short, attached to the body-wall by radiating muscle-fibres. The two respiratory trees are well developed and copiously branched as usual.

There are four long, narrow Polian vesicles, and a single dorsal madreporic canal running in the mesentery close to the genital duct as usual. The Polian vesicles and madreporic canal are arranged at approximately equal intervals round the ambulacral ring. The ampullæ of the tube-feet are few and small.

The reproductive organs consist of two bunches of short cæca attached one on each side to the dorsal mesentery far forward, alongside the œsophagus.

The spicules are small, oval, reticulate plates (Pl. 7. figs. 70–72), very sparingly scattered through the integument. Diameter about 0·1 mm. Some of them have small warts on the surface.

The type specimen from which this description was taken was collected at Macquarie Island, and given to me by Professor Parker, and I have since received through Mr. H. Suter four smaller specimens collected at the same place by Mr. A. Hamilton, and evidently belonging to the same species. Two of these still show in spirit a distinct purple tint on the dorsal surface, which appears to be normally quite smooth.

THYONIDIUM LONGIDENTIS, *Hutton*, sp. (Pl. 6. figs. 62–69.)

1872. Thyone longidentis, *Hutton, Cat. Echinoderm. N. Z.* p. 16.

1872. Thyone caudata, *Hutton, Cat. Echinoderm. N. Z.* p. 16.

1879. Pentadactyla longidentis, *Hutton, Trans. N. Z. Inst.* vol. xi. p. 307.

1886. Thyonidium rugosum, *Théel, 'Challenger' Holothurioidea*, p. 95, pl. v. fig. 5.

1886. Thyone longidentis, *Théel, 'Challenger' Holothurioidea*, p. 141.

1886. Thyonidium caudatum, *Théel, 'Challenger' Holothurioidea*, p. 147.

1891. Phyllophorus caudatus, *Ludwig, Bronn's Klassen und Ordnungen, Echinodermen*, p. 347.

1891. Phyllophorus rugosus, *Ludwig, Bronn's Klassen und Ordnungen, Echinodermen*, p. 347.

It is only after much trouble that I have arrived at the conclusions expressed in the above synonymy, from which it will be seen that I regard three "species" hitherto kept separate as identical. My chief reasons for this conclusion are—the identity in structure of the extremely complex calcareous ring in all three, the identity

in spiculation, and the identity in locality; the condition of the type specimen of *T. longidentis* being such as to preclude detailed comparison in other respects.

I regret to have to differ from the opinion of so great an authority as Théel, who, while redescribing *T. caudatum* from specimens furnished by Captain Hutton, also describes his own *T. rugosum* as distinct; but I cannot help thinking that there has been some oversight here, and that an impartial observer would admit that Théel's own descriptions are almost sufficient to establish the identity of the two.

In order to justify my conclusions I must now discuss the evidence in some detail.

The original description of Hutton's *Thyone longidentis* runs as follows:—

"Cylindrical; body rugose, with numerous small suckers; head smooth, transversely striated; tentacula five, short, thick, clavate, pedunculated, frondose; dental apparatus very long, nearly half the length of the body, tubular for half its length, the rest cut into five teeth.

"Brown, tenacula pale brown.

"About an inch in length.

"The dental apparatus is composed of five plates, each bifid for half its length, joined to one another, and the lateral process of the two adjacent plates together form a tooth."

In 1879 Captain Hutton changed the name to "*Pentadactyla longidentis*," erecting the new genus *Pentadactyla* especially for the reception of this species, with the generic diagnosis—"Feet evenly spread over the greater part of the body. Tentacles five, pedunculated, frondose; dental apparatus very large." He also observes of the species, "It is, however, evident that it is not a *Thyone*, but belongs to the family *Aspidochirotæ*." Why this conclusion should have been arrived at is difficult to see, for the author describes the tentacles as "frondose," and I find from examination of the type specimen that well-developed retractor muscles are present. Théel, no doubt correctly, supposes the species to be a Dendrochirote, though possibly not a *Thyone*.

Unfortunately, the type specimen (from the Wellington Museum) was represented merely by the empty skin, from which all the viscera have been removed, and by the separated pharynx (in the same bottle) with the calcareous ring intact (Pl. 6. fig. 62)

and two retractor muscles still attached. The tentacles had apparently been removed.

The calcareous ring (Pl. 6. fig. 62) is very complex, made up of many small pieces, and agreeing minutely in structure with that of Théel's *Thyonidium rugosum*, as figured in the 'Challenger' Report.

The spicules (Pl. 6. figs. 63–65), abundantly scattered through the integument, are perforated plates, or, as Théel calls them, "tables," each with a conical central spine or "spire" on one side. The spire is made up of two rods united apically. These spicules differ from those figured by Théel for his *Thyonidium rugosum* only in that a great many of them are irregularly quadriradiate in outline. They measure about 0·38 mm. in maximum diameter. The spires appear foreshortened in the figures; they may attain a length of at least 0·18 mm.

If Captain Hutton's observations on the number of tentacles were correct, it would seem inevitable that this specimen should form the type of a distinct genus, as he proposed. On the other hand, the detailed agreement of the very complicated calcareous ring with that of Théel's *Thyonidium rugosum*, which was obtained by the 'Challenger' from near Wellington, together with the close agreement in spiculation and in external characters, including the pedials, which in both cases are wart-like with retractile ends only, convince me that the two are really identical. The tentacles may easily have been wrongly counted in the first instance, for it is by no means easy to make sure of the number when they are bunched together in spirit specimens. Only the apparent slight difference in spiculation then remains to be accounted for, and this is probably more apparent than real and does not amount to a specific distinction.

Turning now to Hutton's *Thyone caudata*, we find the original description as follows:—

"Cylindrical, tapering rather suddenly to the tail; body rough, covered with papillæ, except the posterior end, which is transversely ridged; tentacula ten, moderate, peduncled and frondose; dental system large, with five bifid teeth.

"Reddish brown, paler at the extremities.

"Length 2·5; breadth ·5."

This species was redescribed by Théel from specimens furnished by Captain Hutton, and in the same work the author

describes his *Thyonidium rugosum*, also from New Zealand. Of both species he remarks that they are nearly allied to *Thyonidium japonicum*, and yet he does not seem to have been struck with their resemblance to one another. His descriptions alone, as already pointed out, are almost sufficient to establish the identity of the two, there being only two apparent points of difference worthy of notice, the first concerning the number and arrangement of the tentacles, and the second the structure of the calcareous ring.

Before proceeding to discuss these points, I should say that I have examined a specimen labelled *Thyone caudata*, received from the Dunedin Museum, and a type-slide of spicules given to me by Captain Hutton and bearing the same name.

Now as regards the number and arrangement of the tentacles, I find that in the Dunedin specimen there are actually only nineteen tentacles, five pairs of small alternating with four and a half pairs of very much larger ones, and the smaller ones lying slightly inside the larger. Thus one of the larger tentacles has apparently been removed, accidentally or otherwise; and I have no doubt the arrangement was originally typical, there being twenty tentacles arranged in an outer circle of five pairs of larger ones and an inner circle of five alternating pairs of smaller ones. I venture to think that in Théel's specimen the arrangement of the tentacles was really the same, but that *two* of them have been lost. His description strongly confirms this view of the case. He says:—"The tentacles are retracted, their true position being difficult to determine. In conformity with the general condition in the genus *Thyonidium*, the tentacles are unequal and arranged in pairs, five pairs being several times smaller than the eight remaining tentacles, which are distributed as three pairs and two odd tentacles. Thus, these species deviate from the typical forms with twenty tentacles by the circumstance that two of the tentacles are unpaired."

As regards the calcareous ring, we find that in the case of "*Thyonidium rugosum*" Théel figures but does not really describe it, while in the case of "*T. caudatum*" he describes but does not figure it. It is evident, however, that the ring is practically identical in the two. In "*T. caudatum*" it is described as ending posteriorly in "five slender bifurcate prolongations." Hutton also speaks of "five bifid teeth." I must confess that these descriptions alone do not convey a very clear idea to my mind.

On referring to the Dunedin specimen of "*T. caudatum*," however, I found the calcareous ring (fig. 66) to be practically identical in structure with that figured by Théel for "*T. rugosum*," and also with that of the type specimen of *T. longidentis* (compare figs. 62 and 66). Now neither the actual specimens nor the figure referred to show what I should term "five slender bifurcate prolongations" or "bifid teeth;" and I am inclined to think that there has been a good deal of confusion in the terminology and description of the parts of this very complex structure. Again, in describing *T. longidentis*, Hutton says—"The dental aparatus is composed of five plates, each bifid for half its length, joined to one another, and the lateral process of the two adjacent plates together form a tooth." As a matter of fact each interradial plate bifurcates posteriorly and the divisions unite in pairs to form the five slender radial prolongations or teeth, exactly as shown in Théel's figure for "*T. rugosum*."

I found in the Dunedin specimen a single madreporic canal and a single much elongated Polian vesicle placed nearly opposite to it. The spicules (Pl. **6**. figs. 67–69) are like those figured by Théel for "*T. rugosum*;" but both in the Dunedin specimen and in Hutton's type-slide of "*T. caudata*" there are plenty of irregularly quadriradiate ones like those of the type of *T. longidentis*.

Comparison of Théel's figures of the spicules and calcareous ring of "*T. rugosum*" and my figs. 62–69, representing the corresponding parts in "*T. caudata*" and *T. longidentis*, will, I think, leave little doubt in the mind of the reader that the three are specifically identical.

Stichopus mollis, *Hutton*, sp. (Pl. **7**. figs. 73–82.)

1872. Holothuria mollis, *Hutton, Cat. Echinoderm. N. Z.* p. 15.

1879. Holothuria mollis, *Hutton, Trans. N. Z. Inst.* vol. xi. p. 308.

1886. Holothuria mollis, *Théel, 'Challenger' Holothurioidea*, p. 239.

1886. Stichopus sordidus, *Théel, 'Challenger' Holothurioidea*, p. 167, pl. viii. fig. 3.

The original description runs as follows:—"Body soft, tapering slightly posteriorly; a row of large tubercles like suckers on each side, and another row of fewer suckers on each side of the back; lower surface with many small suckers irregularly placed; tentacles twenty, shortly peduncled, on hollow cylinders, and ending in frondose appendages, which are

longer on the outside; dental apparatus short; respiratory organs moderately branched; longitudinal muscles very broad.

"Yellowish, largely mottled with brown above, and in a lesser degree below; tentacles yellowish brown.

"About 6 inches in length, and $1\frac{1}{2}$ in breadth.

"The suckers are arranged in five rows, but the two upper ones are nearly obsolete; the three other rows are near together, and often run one into the other; from two to four abreast in a row; these five rows can be well seen near the posterior end, when the intestine and muscular tissue has been removed."

In 1879 (*loc. cit.*) Hutton observes, "This species in many respects approaches *Stichopus*. I have had no specimens for dissection, and cannot therefore say whether the reproductive organs are in one or two bunches. A knowledge of this will settle to which genus it should be referred."

My own dissections show that the reproductive organs are arranged in two bunches, and the species must therefore be referred to the genus *Stichopus*.

Théel quotes Hutton's species in a list of imperfectly known forms, but I think there can be no doubt that his *Stichopus sordidus*, which the 'Challenger' obtained plentifully in Cook Straits, is identical therewith.

Thanks to the kindness of Mr. H. B. Kirk, I was able myself to collect specimens in Cook Straits, in the neighbourhood of Wellington, where the species is abundant in rock-pools, and also to make observations on the living animal. Hutton's type specimen appears to be no longer in existence, but I have examined carefully a type-slide of spicules prepared by him, and I do not think there can be any doubt of the identification.

Probably the living animal varies considerably in colour. Hutton described it as yellowish, mottled with brown, but the usual colour appears to be nearly black, and it is possible, as we shall see presently, that some of the light-coloured specimens may belong to a distinct species. One specimen, however, which undoubtedly belongs to Hutton's species, was during life "an even white, not striped, on the ventral surface," as I am informed by Mr. Kirk.

The dorsal processes in life are very conspicuous, large and sharply conical, some of them forming a crown around the ventrally situated mouth, as described by Théel. The tube-feet are numerous, and in life appear to be irregularly scattered over

the ventral surface, but in spirit specimens an arrangement in three broad, ill-defined bands is recognizable. The living animal attains a considerable size, but varies much according to its state of contraction. In spirit it becomes very much contracted and deeply corrugated, the conical projections being withdrawn. It is very difficult to prevent the animal from discharging its viscera when one attempts to preserve it.

The internal anatomy is typical. There is a bunch of long, slender genital tubes on each side of the dorsal mesentery, situated very near the anterior end. There is a pair of well-developed respiratory trees. The calcareous ring (Pl. 7. fig. 82) consists of ten short and simple pieces, the radials being larger than the interradials, and both notched posteriorly. The tentacular ampullæ are finger-shaped and well developed. There is a single large, inflated Polian vesicle placed ventrally, and a single unbranched madreporic canal running forwards in the dorsal mesentery.

The most abundant spicules are the usual "tables" characteristic of the genus (Pl. 7. figs. 73–77), with basal plates about 0·06 mm. in diameter. In addition to these occur thin, reticulate, bilateral plates (Pl. 7. figs. 78, 79), as mentioned by Théel, and curved rods (Pl. 7. figs. 80, 81).

One specimen, also found near Wellington, contains in addition large numbers of another and very peculiar type of spicule in the integument. These spicules are represented in figs. 83–87. They might be described as *dichotomously foliaceous*, and are apparently in fundamental constitution akin to those described by Bell for *Cucumaria inconspicua* * from Port Phillip Heads. They measure about 0·03 mm. in greatest diameter. The specimen in which they occur is of a much lighter colour than usual, in spirit being of a mottled yellowish brown. I can, however, detect no other points of distinction. External characters, the number of tentacles (20), the calcareous ring, the single Polian vesicle and madreporic canal, the tentacular ampullæ, all appear to agree with the corresponding structures in *S. mollis*. Under these circumstances I prefer to await further information before erecting a new species.

HOLOTHURIA ROBSONI, *Hutton*.

1879. Holothuria Robsoni, *Hutton, Trans. N. Z. Inst.* vol. vi. p. 308.
1886. Holothuria Robsoni, *Théel, 'Challenger' Holothurioidea*, p. 239.

* BELL, F. J. Proc. Zool. Soc. Lond. 1887, p. 532.

The original description runs as follows :—" Elongated, rather slender. Skin, smooth. Feet, scattered sporadically over the ventral surface, apparently none on the back. Tentacles, 20. Anus, round. Back, pale purplish brown. Ventral surface, dirty white, with scattered brown spots. Length, $4\frac{1}{2}$ inches.

" Cape Campbell. Presented to the Museum by Mr. C. H. Robson, to whom I have much pleasure in dedicating it."

I am informed by Professor Parker that the type specimen was sent to the Colonial and Indian Exhibition and thence to the British Museum. Nothing further is known of the species.

HOLOTHURIA LACTEA, *Théel.*

Holothuria lactea, *Théel, 'Challenger' Holothurioidea,* p. 183, pl. x. figs. 9, 15.

This is a deep-water species, obtained by the 'Challenger' at Station 169, East of New Zealand, at a depth of 700 fathoms, and also at Station 78, in the North Atlantic, at a depth of 1000 fathoms.

APPENDIX.

On the Structure and Growth Changes of the Wheels in Chirodota dunedinensis.

The fully-developed wheel lies in the integument with its two faces parallel to the surface of the body. The two faces differ very markedly in structure, and, as the position appears to be constant, we may conveniently distinguish them as the inner and outer faces respectively.

The outer face is shown in Pl. 3. fig. 1; from which it will be seen that there is a small round hole in the centre, from which the six flattened spokes radiate to the margin of the wheel. At the margin the ends of the spokes are connected together by the rim, which is strongly incurved on this face and provided with a finely serrated edge.

The inner face of the wheel is shown in fig. 2. Here we see in the middle a six-rayed cross, covering over a central depression or cavity in which lies the small round hole already seen on the outer face. The rays of the cross are much narrower than the corresponding spokes, into which they merge at their outer ends.

Fig. 2 *a* represents an optical vertical section of the wheel; passing through two spokes, through the centre of the cross and through the hole in the outer face, which is here placed lower-

most. The strong curvature of the spokes is well seen, and also the central cavity, with the cross on one side and the small round hole on the other.

We may now pass on to describe the growth changes of the wheel. It has long been known that it first appears as a six-rayed cross, and I find that this cross persists as the cross on the inner face of the fully-formed spicule.

In the earliest stage which I have met with (Pl. **3**. fig. 3) there is already a thickening at the end of each ray of the primary cross and on its outer face. These thickenings increase in size and extend both outwards (towards the outer surface of the integument), and centripetally (towards the centre of the cross), till they meet together (figs. 3 *a*, 4), leaving a hexagonal aperture in the middle. The lines of junction between the adjacent thickenings are at first clearly visible (figs. 4, 5), but they presently disappear, and at the same time the margin of the aperture becomes rounded off. Thus is formed the small round hole seen in the middle of the outer face of the fully-formed spicule.

Meanwhile the thickening of each primary ray has also been extending centrifugally to form one of the six spokes of the wheel, each of which is for some time irregularly bifid at its extremity (figs. 4, 5). When the spokes have attained their full length their ends thicken laterally and on the outer aspect, and these thickenings, meeting and fusing, form the rim of the wheel, in the manner well known for other species.*

It is the formation of the first, centripetal thickenings and the consequent development of the small round hole on the outer face of the spicule which have not, so far as I am able to ascertain, been hitherto described.

EXPLANATION OF THE PLATES.

Plate 3.

Figs. 1–8. *Chirodota dunedinensis.*

Figs. 1–2. Wheels, viewed from the two surfaces and represented as opaque objects. (Zeiss D, Oc. 2, Camera.)

Fig. 2 *a*. Optical vertical section of wheel.

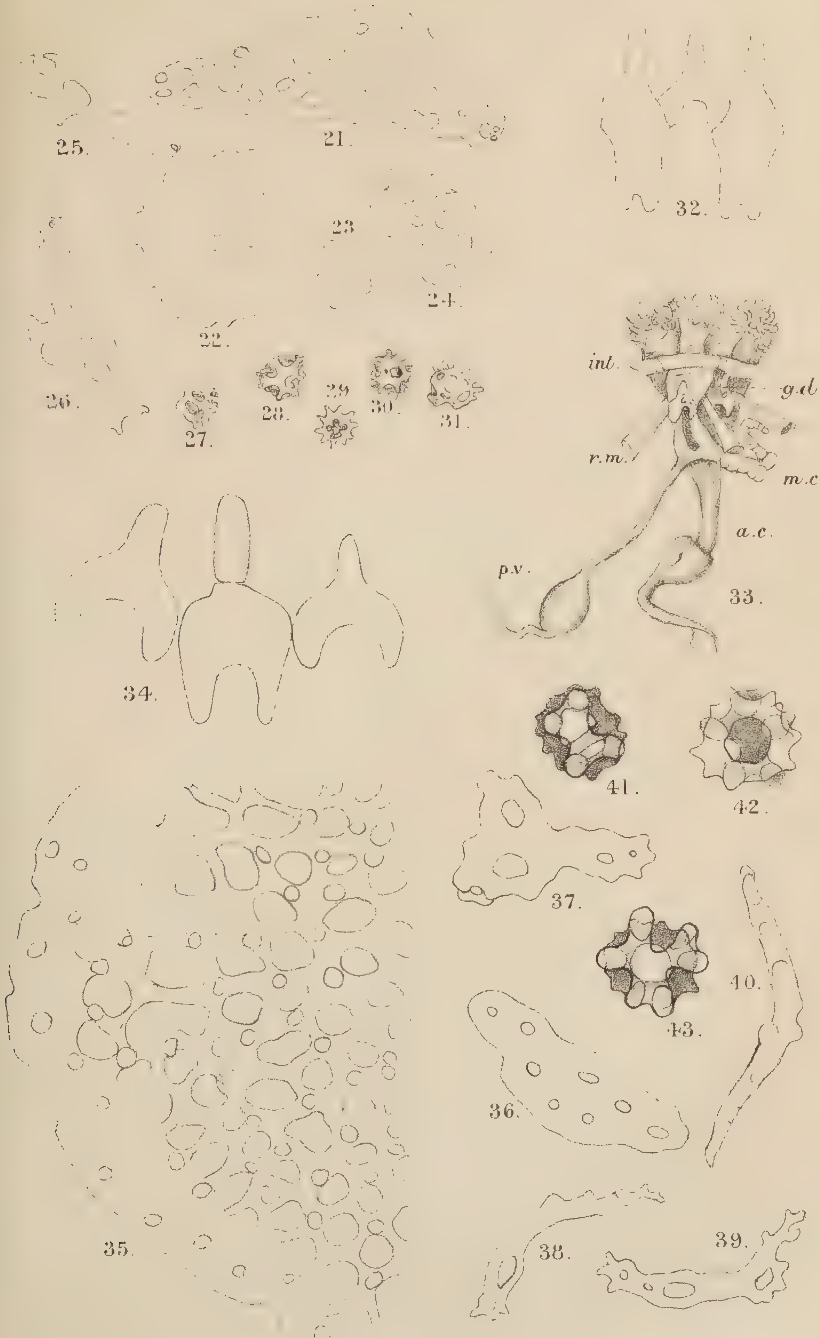
3. Early stage in the development of the wheel, the ends of the primary rays just commencing to thicken. (Zeiss D, Oc. 2, Camera.)

* *Cf.* Ludwig in Bronn's Klass. u. Ordnung. d. Thier-Reichs, Bd. ii. Abth. 3 (Echinod.), p. 55, and also Kishinouye, Zool. Anz. Bd. xvii. p. 146.

Arthur Dendy del.
F.H Michael lith.

Mintern Bros. imp.

HOLOTHURIANS OF NEW ZEALAND.



Arthur Dendy del.
F.H. Michael lith.

Mintern Bros. imp.

HOLOTHURIANS OF NEW ZEALAND.

Arthur Dendy del.
F. H. Michael lith.

Mintern Bros. imp.

HOLOTHURIANS OF NEW ZEALAND.

Fig. 3 *a*. Optical vertical section of slightly later stage, with the thickening greatly increased.

Figs. 4–5. Later stages; the thickenings have met together so as to enclose a hexagonal aperture. (Zeiss D, Oc. 2, Camera.)

(In figs. 3, 4, 5 the primary six-rayed cross is shaded and the spicule is represented as transparent.)

Fig. 6. Later stage, represented as an opaque object and showing the commencement of the rim of the wheel. (Zeiss D, Oc. 2, Camera.)

7. Sigma-shaped spicules. (Zeiss D, Oc. 2, Camera.)

8. Part of calcareous ring, × 12.

Figs. 9–18. *Caudina coriacea.*

Figs. 9–11. Characteristic spicules of the integument. (Zeiss D, Oc. 2, Camera.)

12–14. Irregular spicules from tip of tail. (Zeiss D, Oc. 2, Camera.)

Fig. 15. Coloured corpuscles of the cœlomic fluid. (Zeiss D, Oc. 3.)

15 *a*. Group of similar corpuscles, polygonal from mutual pressure. (Zeiss D, Oc. 3.)

16. Large, coarsely granular, colourless corpuscle from the cœlomic fluid. (Zeiss D, Oc. 3.)

17. Small, finely granular, colourless corpuscles from the cœlomic fluid. (Zeiss D, Oc. 3.)

18. Part of calcareous ring, × 3. (A few transverse cracks, apparently accidental, have been omitted.)

Figs. 19, 20. *Cucumaria Huttoni.*

Fig. 19. Pharynx, showing calcareous ring, &c., × 2. *i.*, interradial plate; *r.*, radial plate; *r.m.*, retractor muscles; *m.c.*, madreporic canal; *p.v.*, Polian vesicles; *a.c.*, alimentary canal.

20. Small reticulate plate from integument. (Zeiss D, Oc. 2, Camera.)

Plate 4.

Figs. 21–32. *Colochirus alba.* (Specimen from the Wellington Museum.)

Figs. 21–24. Small reticulate plates from integument. (Zeiss D, Oc. 2, Camera.)

25–26. Perforated rods. (Zeiss D, Oc. 2, Camera.)

27–31. Reticulate cups from different points of view. (Zeiss D, Oc. 2, Camera.)

Fig. 32. Part of calcareous ring, × 13.

Figs. 33–43. *Colochirus ocnoides.* (Specimen from New Brighton.)

Fig. 33. Dissection, showing pharynx, crown of tentacles, &c., × 3. *i.*, interradial plate; *r.m.*, retractor muscles; *m.c.*, madreporic canal; *p.v.*, Polian vesicle; *a.c.*, alimentary canal; *g.d.*, upper end of genital duct; *int.*, integument around crown of tentacles.

34. Part of calcareous ring, × 15. (The crack across the radial plate is probably accidental.)

35. Part of large reticulate plate from integument. (Zeiss D, Oc. 2, Camera.)

36. Small reticulate plate from integument. (Zeiss D, Oc. 2, Camera.)

Figs. 37–39. Perforated rods. (Zeiss D, Oc. 2, Camera.)

Fig. 40. Side view of rod. (Zeiss D, Oc. 2, Camera.)

Figs. 41–43. Reticulate cups from different points of view. (Zeiss D, Oc. 2, Camera.)

Plate 5.

Figs. 44–53. *Colochirus calcarea.*

Figs. 44–47. Knobbed reticulate plates from integument. (Zeiss D, Oc. 2, Camera. 46 in profile.)

48–49. Knobbed reticulate cups. (Zeiss D, Oc. 2, Camera.)

50–52. Perforated rods. (Zeiss D, Oc. 2, Camera.)

Fig. 53. Part of calcareous ring, drawn from microscopical preparation and slightly restored. × 30.

Figs. 54–61. *Colochirus brevidentis.* (Specimen from Wellington Museum.)

Figs. 54–57. Knobbed reticulate plates from integument. (Zeiss D, Oc. 2, Camera.)

58–60. Small knobbed reticulate plates. (Zeiss D, Oc. 2, Camera.)

Fig. 61. Perforated rod. (Zeiss D, Oc. 2, Camera.)

Plate 6.

Figs. 62–65. *Thyonidium longidentis.* (Type specimen from Wellington Museum.)

Fig. 62. Calcareous ring, in a much contracted condition, × 8.

Figs. 63–65. Reticulate plates from integument. (Zeiss C, Oc. 2, Camera.)

Figs. 66–69. *Thyonidium longidentis.* (Specimen from Dunedin Museum, labelled *Thyone caudata.*)

Fig. 66. Sketch of portion of calcareous ring, × 5½.

(The outlines between the polygonal plates are in parts very difficult to make out, and the drawing does not pretend to absolute accuracy in this respect.)

Figs. 67–69. Reticulate plates from integument. (Zeiss C, Oc. 2, Camera.)

Plate 7.

Figs. 70–72. *Psolus macquariensis.*

Reticulate plates from integument. (Zeiss D, Oc. 2, Camera.)

Figs. 73–82. *Stichopus mollis.*

Figs. 73–77. Characteristic spicules ("Tables") from various points of view.

78–79. Thin reticulate bilateral plates.

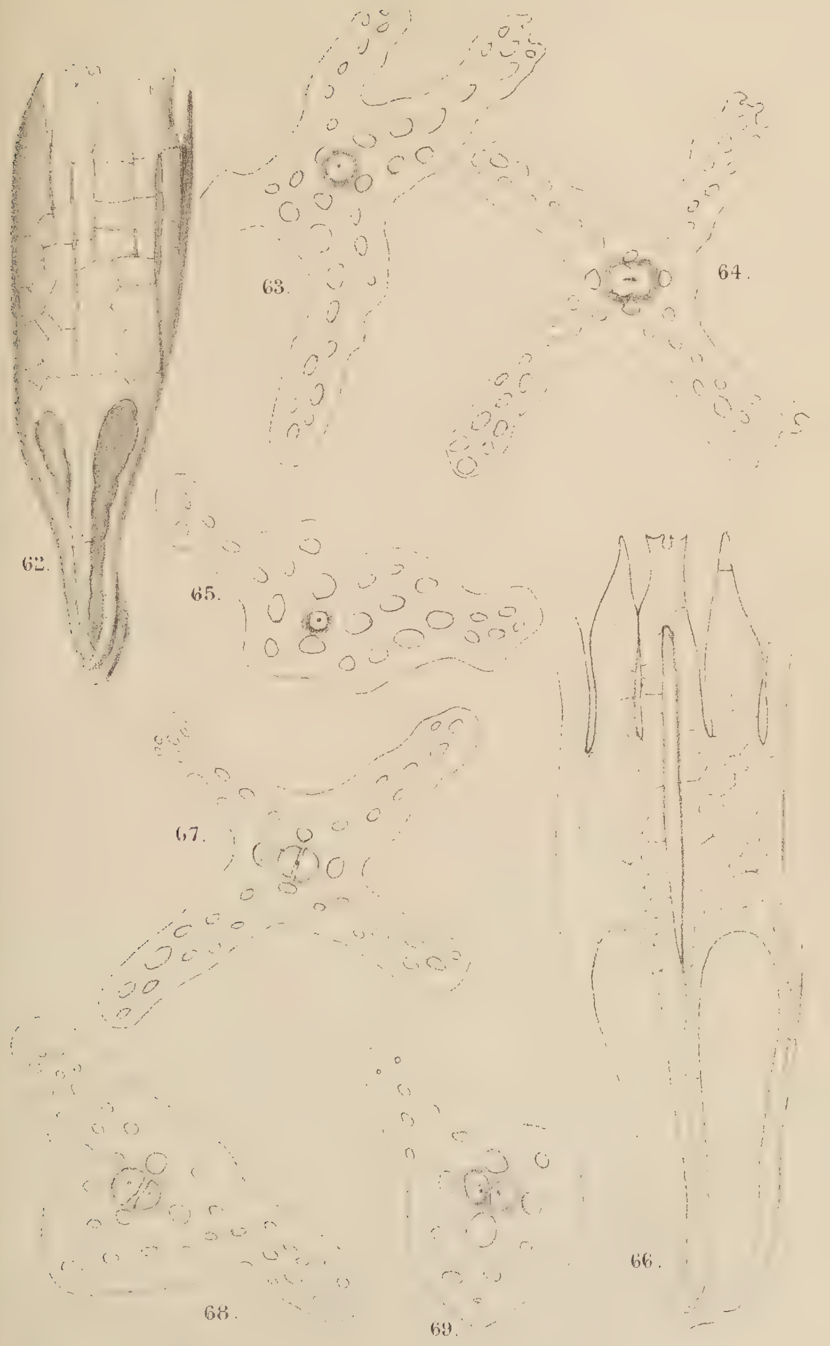
80–81. Curved rods.

(Figs. 73–81 drawn from Capt. Hutton's type slide; Zeiss D, Oc. 2, Camera.)

Fig. 82. Part of calcareous ring, × 2½.

Figs. 83–87. *Stichopus mollis?*

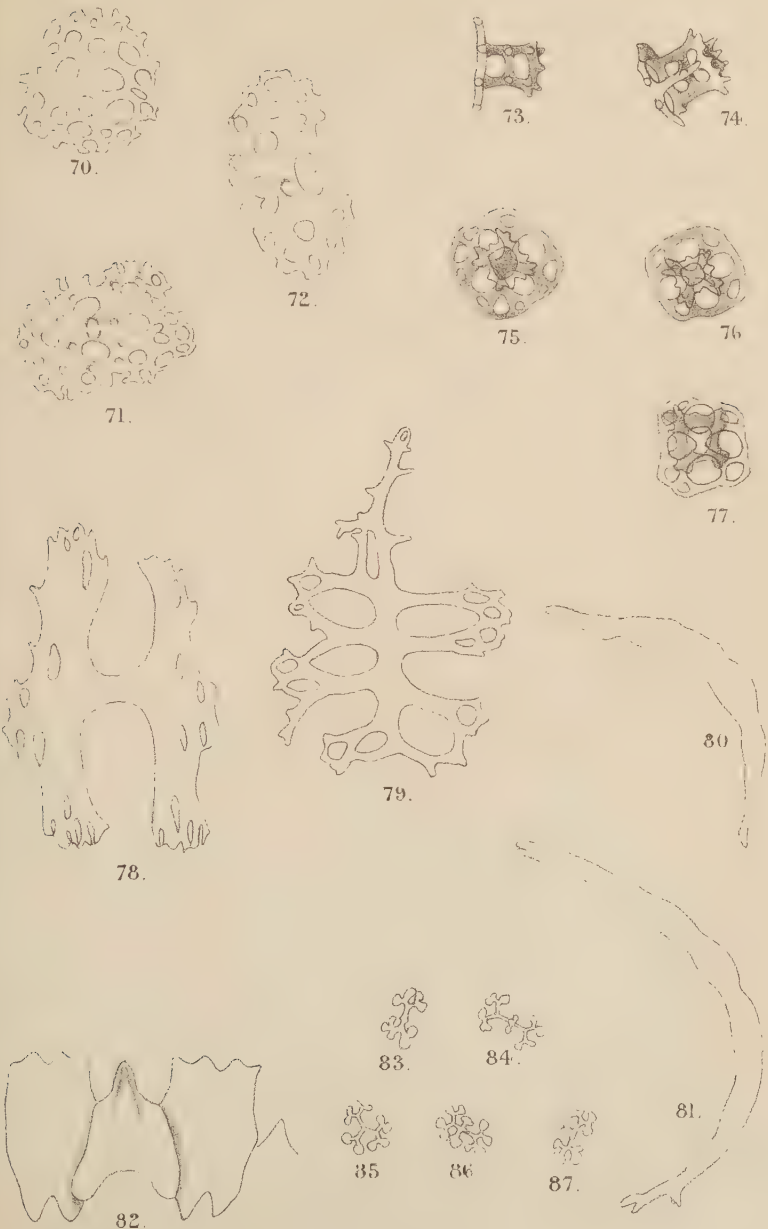
Additional spicules from a yellow specimen collected near Wellington (Zeiss D, Oc. 2, Camera.)



Arthur Dendy del.
F. H. Michael lith.

Mintern Bros. imp.

HOLOTHURIANS OF NEW ZEALAND.



Arthur Dendy del.
F H. Michael lith.
Mintern Bros. imp.

HOLOTHURIANS OF NEW ZEALAND.

On the Structure and Development of the Hyobranchial Skeleton and Larynx in *Xenopus* and *Pipa*; with Remarks on the Affinities of the Aglossa. By W. G. Ridewood, B.Sc., F.L.S., Lecturer on Biology at St. Mary's Hospital Medical School, London.

[Read 19th November, 1896.]

(Plates 8–11.)

Contents.

Introduction.

Considerable interest has for many years centred around the little suborder of the Anura Aglossa and the question of the affinities of the two sole genera, *inter se*, and with other Anura. *Pipa* and *Xenopus*, so remote from one another geographically and so essentially different in general configuration, size, dentition, spawning-habits, and many peculiarities of internal structure, yet exhibit numerous anatomical resemblances which appear to point conclusively to a common ancestry. Standing out prominently from among the latter characteristics is the remarkable complexity of the larynx and the extraordinary sexual dimorphism which it exhibits. It is with this organ that the present paper essentially deals. It both *Pipa* and *Xenopus* the relation of the larynx to the hyobranchial skeleton is so intimate, that a minute

study of the latter is necessarily demanded; and, in order to insure the correctness of the morphological value attributed to the various parts, a chapter on the development of the hyobranchial skeleton is added. I have studiously avoided all reference to the columella auris and stapedial cartilages, since these are not related anatomically with the larynx. The expression "hyobranchial skeleton," therefore, is here used in a limited and strained sense; but I do not think that any confusion is likely to be caused by this departure from the strict application of the words.

Passing over the works of Fermin (**13**) and Schneider (**37**), who mention only incidentally the hyobranchial and laryngeal skeleton of *Pipa*—*Xenopus* was not then known,—the first description of these parts occurs in a short monograph by Breyer on *Pipa* (**4**. 1811). Mayer (**25**) in his treatise on the same animal, published fourteen years later, describes for the first time the muscular system. He furnishes a detailed account of the larynx of both sexes; but the description suffers considerably from the lack of pictorial illustration. In his second contribution (**26**. 1835) he describes the muscles of the hyoid apparatus of *Xenopus*, and treats of the laryngeal skeleton of both sexes. To his figures of the *Xenopus* larynx (Taf. 3. figs. 6 & 7) he adds, for purposes of comparison, one of the larynx of the male *Pipa* (Taf. 3. fig. 5). By far the greater part of our present knowledge of the subject we owe to the patient and exhaustive investigations of Henle (**19**). Although his book refers to the vertebrate larynx generally, he has devoted quite an exceptional amount of space to the aglossal toads, and has allotted to them the whole of one of the five plates by which his work is so admirably illustrated. He describes with great care the hyobranchial skeleton of *Xenopus* and *Pipa*, the laryngeal skeleton of both sexes, and the laryngeal muscular system of the female *Pipa* and the male *Xenopus*. Henle was the first to suggest (p. 15) that the hyoglossal foramen, so characteristic of the Aglossa, is formed by a union of the anterior or hyoidean cornua, and that the hind edge of the foramen corresponds with the notch at the front of the body of the hyoid in other Anura. He agrees (p. 16) with Meckel (**27**. p. 229) and Mayer (**26**. p. 31), that the anterior cornua have been reduced in *Pipa* and are only represented by the delicate pointed cartilage at the front of the hyobranchial apparatus. Henle also (p. 16) propounded the view, already hinted at by Mayer (**25**. p. 541, and **26**. p. 31), that the anterior

portion of the ventral wall of the larynx of both *Xenopus* and *Pipa* is in reality the hinder part of the median hyobranchial plate, and that the rod-like ossifications in the laryngeal skeleton are the columellæ or thyrohyal bones of other Anura.

The account given by Hoffmann (20) is culled almost entirely from Henle's treatise, many paragraphs being verbatim extracts. Hoffmann, however, does not seem to have had a clear idea of the nature of the coalescence of the skeletal parts described by Henle; for in two places he speaks of a fusion of the *arytenoid* cartilage with the body of the hyoid, unjustifiably substituting "cartilago-arytænoidea" in the one place (p. 518) for "Stimmladenknorpel" of Henle (p. 16), and in the other (p. 524) for "Ringförmiger Knorpel" of the same author (p. 26). Parker (33), in his exhaustive work on the skull of Batrachia, gives good figures of the hyobranchial skeleton of larval and adult stages of both *Xenopus* and *Pipa*. He ignores Henle's view of the mode of formation of the hyoglossal foramen, and by labelling the cartilage which bounds it in front the first basibranchial, tacitly suggests its origin as a secondary fenestration in the body of the hyoid. He considers the great lateral expansion of the hyobranchial skeleton of both *Xenopus* and *Pipa* as a derivative of the first and second branchial arches, and the thyrohyal as formed from the third and fourth.

Cope (7) copies Parker's figure of the hyobranchial skeleton of *Xenopus*, and gives a new interpretation to the parts, the lateral wing being considered as derived from the first, and the thyrohyal from the second branchial arch. The paper is, however, marred by contradictory statements, and the views expounded in the text do not accord with those expressed by the figure. Grönberg (18) furnishes outline text-figures of the hyobranchial skeleton of *Xenopus* and *Pipa* (p. 636), and several excellent illustrations of the larynx of both sexes of *Pipa* (Taf. 38. figs. 10–20). He pays most attention to the larynx of the male, and treats of the intrinsic laryngeal muscles of this sex alone. He regards the *whole* of the floor of the larynx of *Pipa* as derived from the branchial skeleton, and compares it (p. 635) with the cartilago thyreoidea of mammals. Wilder, in his admirable paper on the Amphibian larynx, devotes a couple of pages (42. pp. 291–292) to the hyobranchial and laryngeal skeleton of the Aglossa, and gives four figures (Taf. 21. figs. 58–61) of these structures in *Xenopus*. He refers also to the laryngeal musculature of this genus. Unfortunately his observations on the Aglossa

are not of the same standard of excellence as the rest of the work.

Such, briefly stated, is the extent of our present knowledge on the subject. With the various conflicting views and contradictory statements before me, I set myself to ascertain to what extent, if at all, the hyobranchial skeleton enters into the formation of the laryngeal box in the Aglossa; whether the lateral laryngeal ossifications of *Xenopus* are really the thyrohyals, and whether the ossifications in the floor of the larynx of *Pipa* are homologous with these. A further object of the investigation was the determination of the morphological value of the great wings of the hyobranchial skeleton in *Xenopus* and *Pipa*; the experimental verification of the assumed absence of the hyoidean cornua in *Pipa*; and an inquiry into the functional value of the great arytenoid rods which lie in the interior of the larynx in the male of this genus. The results of the investigation are arranged in the following order:—First, a comparative treatment of the adult hyobranchial skeleton of *Xenopus* and *Pipa*, including a detailed account of the laryngeal skeleton of both sexes; then a description of the laryngeal muscles of the two genera; the details of the development of the hyobranchial and laryngeal skeleton; and, in conclusion, a few observations on the bearing of the facts on the problem of the affinities of *Xenopus* and *Pipa* to one another and to the tongued Anura.

Before proceeding farther, I take the opportunity of expressing my grateful acknowledgments to Sir William Flower, K.C.B., for placing in my way every facility for the execution of this research. In addition to the adults of *Xenopus* and *Pipa*, which by the kindness of Sir William Flower I was permitted to examine at the Natural History Museum, I have received numerous specimens, both larval and adult, from Prof. G. B. Howes, of the Royal College of Science, Mr. F. E. Beddard, F.R.S., and Mr. G. A. Boulenger, F.R.S.; and to them my thanks are hereby gratefully tendered.

Hyobranchial Skeleton of *Xenopus lævis*, female.

In describing the hyobranchial and laryngeal skeleton of the Aglossa it is advisable to commence with that of the female *Xenopus*, firstly, because in *Xenopus* this portion of the skeleton is less aberrant than in *Pipa*, and, secondly, because the modification is less in the female than in the male. By choosing the

simplest of the four, we experience less difficulty in instituting a comparison with the more familiar tongued Anura; and, after having definitely settled the morphological value of each skeletal part, we can readily proceed to ascertain how the more modified parts in the other three are related to those of the first. As in other Anura, so in the Aglossa, it is impossible to draw, in the hyoid apparatus of the adult, a sharp line of demarcation between those structures which are hyoidean and those which are branchial in origin. The anterior cornua representing the main portion of the hyoid arch are present in *Xenopus*, but disappear during metamorphosis in *Pipa* (see p. 108). In both genera, however, there is a relic of hyoidean cartilage in the median cartilage situated in front of the hyoglossal foramen.

The first figure published of the hyobranchial skeleton of *Xenopus* is that of Mayer (**26**. Taf. 3. fig. 7). This is fairly correct in detail, but fails to show the hyoglossal foramen. Henle's figure (**19**. Taf. 2. fig. 1), also of the female sex, is far superior. The figure which Parker gives (**33**. Pl. 58. fig. 5) is, on the whole, less useful than Henle's. It shows that the larynx lies between the thyrohyals, but it furnishes no details of the relationship. A similar figure open to the same objection is given by Grönberg (**18**. p. 636, fig. A, ii.), and two others, with the said details introduced though incorrectly, by Wilder (**42**. Pl. 21. figs. 58 and 59).

In the female *Xenopus* the anterior or hyoidean cornu (Pl. **8**. fig. 1, *ch.*) is broad and flat, and consists of a rod-like axis, expanded on its inner and outer edges into very thin and delicate plates of cartilage which have hitherto escaped notice. At the upper posterior end of the arch the axis is unaccompanied by its lamellar expansions; it takes a sharp curve upwards and outwards, and is attached by ligament to the skull about 3 mm. from the articular head of the quadrate. At their anterior or median extremities the cartilaginous rods of the right and left cornua unite at a very obtuse angle. The external lamellæ are continuous in front of this union; but the internal or posterior expansions stop at some distance from the median line. From the point of union of the cornua there extends back a median rod of cartilage (Pl. **8**. fig. 1, *ch.'*), very slightly, if at all, broader than the axes of the cornua. The basal plate or body of the hyoid is produced outwards into two smaller anterior processes (Pl. **8**. fig. 1, *ap.*) fitting closely behind the anterior cornua, and

a pair of very large postero-lateral plates, usually described as the "alæ" or "wings" (Pl. 8. fig. 1, *a*)—a most convenient term, as it merely designates the part without expressing its morphological value. The true value of these processes is discussed later, chiefly upon the evidence furnished by a study of the development. The alæ are perfectly flat plates of cartilage, with an even margin, slightly pointed posteriorly, and with a blunt notch on the mesial edge at about one-fourth of the length from the posterior extremity. The greatest diameter, at about one-third from the posterior end, is rather more than one-third of the length. Mayer (**26**. p. 33) says that in the female *Xenopus* the wings are smaller and thinner than in the male, a statement with which I cannot agree. But since he says (p. 29) the male "ist grösser und schlanker gebaut als das Weibchen," it is evident that his female specimens were not up to the average size, or that his males were exceptionally large. The anterior processes and the alæ are of the same thickness of cartilage as the basal plate itself; but there is a much thinner extension of cartilage, recalling the lamellar expansions of the anterior cornua, which forms the lateral margin. This thins away behind along the external margin of the ala, and is continued forward around the external and anterior edge of the anterior process. It is indicated in Plate **8**. fig. 1 by fainter shading.

The hyoglossal foramen (Pl. **8**. fig. 1, *h*), which is such a conspicuous feature of the hyobranchial apparatus, is mainly closed by membrane: the hyoglossal muscles, which rise up to be distributed to the mucous membrane of the floor of the mouth, pass between the posterior edge of the membrane and the cartilage which bounds the foramen posteriorly (Pl. **8**. fig. 1, *y*). The shape of the fontanelle varies; but it is always oval and elongated in an antero-posterior direction, its greatest diameter lying behind the middle of its length. Henle (**19**. p. 15), with remarkable introspection, considered that the hinder border of this hole in the basal plate represents the anterior edge of the basal plate of the hyobranchial skeleton of the frog, and that the presence of the foramen is to be explained by the union of the two anterior cornua in front. He based his conclusions almost entirely on the relations of the hyoglossal muscles; but, as I hope to prove in the sequel, he was fully justified in his determination. Behind the foramen the basal plate is sharply constricted, but it almost immediately widens out behind, and becomes indistinguishably

fused with the anterior edge of the cricoid cartilage of the floor or ventral wall of the larynx, in the position marked x in fig. 1. The reasons for fixing this as the region of coalescence are based upon a comparison of the cricoid skeleton with that of the frog (see p. 62) and on a study of the development of the parts (see p. 100). The distance yx, therefore, in fig. 1 represents the very greatly diminished antero-posterior diameter of the large basal plate of the frog's hyobranchial skeleton. Henle has already pointed out in the middle of the basal cartilage of *Xenopus* an incipient ossification, which he compares (**19.** p. 17 footnote) with that larger **V**-shaped ossification which occurs in the middle of the body of the hyoid of *Alytes.* The ossification occurs only late in life, so that it is quite possible for the larynx of a sexually mature *Xenopus* to show no trace of it.

Externally to the region of coalescence between the laryngeal cartilage and the basal plate, and separated from it by two small membranous areas, are the anterior ends of two rods of bone which project backwards and, diverging slightly, run along the right and left sides of the larynx proper (Pl. **8**. fig. 1, *t*). These rods are circular in section, are thicker behind than in front, and are narrowest at a short distance from the anterior end. The posterior epiphyses are cartilaginous and exhibit, in fully grown specimens, an incipient endochondral ossification (Pl. **8**. fig. 3, *ep.*). The epiphysis is fused mesially with the hind end of the lateral walls of the cricoid cartilage. The rods are the only fully ossified parts of the whole hyobranchial and laryngeal skeleton; and in this respect, as also in form, they resemble the columellæ or thyrohyals of the tongued Anura *, with which they have been considered homologous by all writers who have given attention to the subject, from Henle onwards. The attachment of the rods to the hind part of the basal plate, their lateral position with regard to the larynx proper, their divergence even, all point to the same conclusion; and, since I hope to prove in the following pages that all the salient features of the cricoid and arytenoid cartilages of the larynx of the frog or other anuran can be distinctly recognized in the cartilaginous apparatus that lies between the two bony rods in the female *Xenopus*, there would appear to be here sufficient evidence, without having recourse to that afforded in addition by a study of the relations of the muscles,

* Ossifications in the body or basal plate occur in *Bombinator*, *Alytes*, and other forms; but even in these the columellæ are the most completely ossified.

and of the development of the rods themselves, to firmly establish the homology. The posterior ends of the thyrohyals are wider apart than the inner edges of the alæ, and lie below or ventral to the latter. The posterior epiphysial cartilages are bound by a very short and tough ligament to the ventral surface of the alæ, just external and slightly posterior to the notch on their inner edge already mentioned.

Laryngeal Skeleton of *Xenopus lævis.*

The first account of the larynx of *Xenopus* is that of Mayer (**26.** 1835). He describes both sexes and gives figures of each (Taf. 3. figs. 6 and 7). Henle (**19**), like Mayer, discusses both sexes, and his figures of the dorsal and ventral surfaces of the female larynx (Taf. 2. figs. 1 and 2) are exceedingly accurate. The larynx described by Wilder (**41.** p. 573, and **42.** pp. 291 and 292) must have been in a sad state indeed if his figures (**42.** Taf. 21. figs. 58–61) represent it at all truthfully. These show a number of dismembered cartilages in the roof, and no cartilage in the floor. It is, also, hardly just and fair to condemn Henle's excellent work and to charge him with overlooking the true arytenoids, on the strength of observations made, as Wilder himself admits (**42.** p. 290), on a single specimen. This most recent contribution of Wilder's is so good in the main that it is a great pity it has been marred by the incorporation of the results of "hasty study."

Female.

The larynx proper of *Xenopus* differs from that of the more normal anuran, not only in its superior size and the extensive spreading of the cricoid cartilage so as to form an almost complete laryngeal box, but more especially in the union of the lateral edges of its floor with the inner surfaces of the ossified thyrohyals, the confluence of the anterior region of the floor with the back of the basal plate of the hyoid, and in the coalescence which has taken place between the posterior epiphysis of the thyrohyal and the postero-lateral corners of the cricoid. Although the lateral edges of the floor of the larynx are so closely applied to the columellæ, the actual sides of the larynx are free, and the narrow space between them and the thyrohyals is filled with a fatty tissue similar to that found on the under surface of various parts of the hyobranchial skeleton. There is a pear-shaped membranous area (Pl. 8. fig. 2, *f*) in the cartila-

ginous side-wall of the larynx, which is of considerable value as a guide to the recognition of homologous parts in *Xenopus* and *Rana* (see p. 62). The floor or ventral wall of the larynx has the form of an extensive plate of cartilage, incomplete only in a pair of elongated membranous areas (Pl. **8**. fig. 1, *f′*) towards its anterior end, where the anterior fifth of the thyrohyal remains free.

The floor of the larynx is produced posteriorly into a pair of cartilaginous bands (*br.*) with very irregular edges, which run back along the mesial surface of the bronchi, in the possession of which latter the Aglossa depart again from the anuran type. The irregular outgrowths from the sides of the bands extend only to the middle of the upper and under surfaces of each bronchus, so that the outer half of the bronchial tube is entirely membranous. These bronchial prolongations of the cricoid cartilage are not unrepresented in other Anura, for in the Discoglossidæ (e. g. *Discoglossus*) two thin cartilaginous bars run back from the floor of the larynx to the under surface of the root of the lung, where they end in a cross-piece, **T**-shaped, which may be regarded as equivalent to one of the bronchial half-rings of *Xenopus*. In *Alytes* these rods are even more elongated than in *Discoglossus*, but the terminal **T**-piece is very little developed. In *Bombinator* the processes are quite short and stout (Pl. **11**. fig. 13, *br.*). Even in *Rana* the opening of the lung into the larynx is supported by a ring of cartilage which sends off irregular processes on to the lung. The strongest of these (Pl. **9**. fig. 7, *br.*), running along the ventro-internal aspect of the lung, would appear to correspond with the process already referred to in the Discoglossidæ, and with the bronchial cartilaginous band of *Xenopus*. The roof of the larynx of the female *Xenopus* is deeply notched behind (Pl. **8**. fig. 3), so that a membranous area intervenes between the cricoid and bronchial cartilages. The anterior edge of the roofing cartilage is delicately rounded, and is rather thicker than the other parts. The antero-posterior diameter of the roof is not more than twice the transverse diameter.

The arytenoid, like the cricoid, is exceptionally shaped. The sides of the glottis are supported by a pair of delicate cartilaginous flaps (Pl. **8**. fig. 3, *ar.*) which, from their relations to the glottis and to the laryngeal muscles, evidently correspond to the arytenoid cartilages as we find them in the common frog. They are continued backwards into relatively massive processes (*ar.′*)

which, behind the glottis, meet one another in the median plane by perfectly flat and smooth articular surfaces *. These masses of cartilage lie immediately in front of the thickened anterior edge of the roofing cartilage of the larynx and usually contain a small centre of ossification each. These ossifications, like those of the posterior epiphyses of the thyrohyals and the anterior part of the floor of the laryngeal complex, only appear with advancing age. A female may be fully grown and sexually mature without exhibiting a trace of ossification in these regions. The lateral motion of the arytenoids is limited by a pair of concavo-convex upgrowths of the side-walls of the larynx (Pl. **8**. fig. 3, *bl.*), called by Henle (p. 17) the "Scheuklappenartige Fortsätze" or blinker-shaped processes. There are no vocal cords, and their absence may account for the exceptional shape and mutual relations of the arytenoids. The failure of the arytenoids to touch one another in front of the glottis is also a matter of no little importance.

The relations that obtain between the cricoid cartilage of *Xenopus* and that of other Anura can best be made out by the study of a median section of the laryngeal skeleton. By this means it is seen that the roofing part of the larynx of *Xenopus* (Pl. **8**. fig. 2, *c*) is nothing more than the median dorsal rod, greatly expanded, of *Rana esculenta* (Pl. **9**. fig. 7, *c*), while the floor (Pl. **8**. fig. 2, *c′c″*) is made up of the coalesced enlarged transverse bars (Pl. **9**. fig. 7, *c′* & *c″*). Even the blinker-shaped processes of *Xenopus* (Pl. **8**. fig. 3, *bl.*) can be recognized in the frog's larynx in the swellings (Pl. **9**. fig. 7, *bl.*) at the sides of the anterior ventral bar of the cricoid. The membranous area (Pl. **8**. fig. 2, *f*) in the side-wall of the larynx of *Xenopus* is a great guide in the determination of the parts, since it fixes the position of the space (Pl. **9**. fig. 7, *f*) at the sides of the ring of cartilage on the ventral surface of the frog's larynx. Owing to the great expanse of cricoid cartilage in *Xenopus*, the connexion with the posterior epiphysis of the thyrohyal, situated in the frog close behind the arytenoid (Pl. **9**. fig. 7, *l′*), is thrown

* Seeing that in the larval larynx (Pl. **11**. fig. 10) the arytenoids are in contact with the anterior edge of the dorsal part of the cricoid, and are even overlapped by it, it becomes doubtful whether, after all, the massive part of the arytenoid of the adult is a *process* of the true arytenoid—it may be simply an *enlargement* of the posterior end. In the male of *Pipa* it is tolerably certain that the bulk of what is known as the arytenoid is really a process of the true arytenoid; but the relations are simpler in *Xenopus*.

very far back (see Pl. 8. fig. 3), and the union is brought about in *Xenopus* by the confluence of the cartilages and not by ligament as in the frog. Henle states (p. 14) that in *Alytes obstetricans*, *Bufo cinereus*, *Rana esculenta*, and *Rana temporaria* the larynx is connected with the epiphysis of the thyrohyal by continuous cartilage. I have examined these four species, and have found the connexion to be ligamentous in all. Wilder refers (42. p. 286) to a cartilaginous union in *Bufo lentiginosus*, but the difficulty of obtaining this species in England has prevented me from checking the observation. Relatively to the size of the whole body, the arytenoids are much smaller in *Xenopus* than in the frog, although the larynx as a whole is very much larger. I have elected to institute this comparison with the larynx of the edible frog, not merely because the figures of the latter by Ecker (12) and others are so familiar to the majority of anatomists, but also because of the fact that the laryngeal skeleton of the female *Xenopus* will bear a closer comparison with that of *Rana esculenta* than with that of any other species of *Rana*. It is true that Wilder (42. p. 287) has shown that the larynx of *Rana esculenta* is not typical of Anura, nor even of the genus *Rana*; but by the very possession of the posterior ventral bar of the cricoid (Pl. 9. fig. 7, *c''*), in which it departs from the other species of the genus, the larynx of the edible frog approaches the nearer to that of *Xenopus*.

In spite of this parallelism existing between the larynx of *Xenopus* and that of the frog, an extensive study of the skeleton of many different genera of Anura has convinced me that that amphibian (*Pipa* excepted) the hyobranchial and laryngeal skeleton of which most nearly approximates to that of *Xenopus* is undoubtedly *Bombinator*—a determination which I had arrived at prior to the publication of the hint to the same effect by Wilder (42. p. 291). The notch at the front of the hyobranchial basal plate in this toad is excessive, so great in fact as to leave only a narrow transverse isthmus connecting the right and left halves, as in some Hylidæ *. The paired ossifications in the

* In spite of the depth of the notch at the front of the basal plate, the point at which the hyoglossal muscles rise above its level is not in any way thrown back. The notch is closed by a membrane, the front edge of which lies nearly straight and is situated a considerable distance in front of the incised cartilage. This holds good also for *Alytes*, *Discoglossus*, *Rana*, *Bufo*, and most Anura where the notch is at all deep. In *Xenopus* the hyoglossal muscles rise immediately in front of the cartilage that forms the posterior border of the oval foramen, while the membrane spreads out in front over the rest of the hole.

body of the hyoid of *Bombinator* are exceptional, and these are not represented in *Xenopus*; but the large size of the lateral processes of the hyobranchial skeleton, more especially the posterior pair, is significant, and the great breadth of the plate-like hyoidean cornua renders them remarkably similar to those of *Xenopus*. The laryngeal skeleton of *Bombinator* is not only expansive and dome-shaped, and larger in the male than in the female, but is also elongated in an antero-posterior direction, especially in the male sex. These features are well illustrated by Wilder (**42**. Taf. 21. figs. 45–47), but in his figures he unfortunately omits the conspicuous bronchial processes that project from the posterior edge of the cricoid cartilage (Pl. **11**. fig. 13, *br.*). The broadening of the cricoid cartilage in *Bombinator* is, as in *Discoglossus* (where, owing to the larger size of the larynx, the fact can be better made out), confined to the roof and floor. The sides consist of mere bands or rods of cartilage extending vertically from roof to floor, and the ligament that runs out to the thyrohyal epiphysis is attached to the middle of the external surface of the bar.

In the Discoglossidæ, as in the Aglossa, there are no traces of what Henle (p. 11) calls the cartilages of Santorini, small abstricted portions of the arytenoid cartilages occurring in a limited number of Anura, and first figured by Saint-Ange (**36**. Pl. 26. figs. 4 & 5). They are the "pre-arytenoid" cartilages of Ecker (**12**) and the "apical" cartilages of Wilder (**42**). The absence of these cartilages, however, cannot be allowed to carry much weight, since they are not constant in closely allied genera, and may even be sometimes missing in the female of a species normally possessing them (**12**. p. 313).

Male.

The sexual differences in the laryngeal skeleton, so striking in the aglossal Anura, are nevertheless not confined to them. Wilder (**42**) has already pointed out that in *Bufo* there are suggestions of sexual dimorphism in the larynx, and that important sexual differences occur in the Hylidæ and in *Bombinator*. But the increased size and complexity of the larynx in the male is even more widely spread among Anura than he indicates. Ecker (**12**. p. 313) has shown that in *Rana esculenta* the arytenoid cartilages are thick, strong and large in the male, and thin, smaller and more hollowed in the female. In *Alytes* and

Discoglossus I find that the sexual differences are quite as strongly marked as in *Bombinator*, while in *Pelobates*, *Ceratophrys*, and *Pelodytes*, although the differences are less pronounced, they are clearly recognizable. It is highly probable that more extended observations will amplify the list still further.

In the male *Xenopus* the larynx, relatively to the size of the hyobranchial skeleton and to that of the whole body, is considerably greater than in the female, but yet, owing to the smaller size of the male as compared with the female, the actual cubic content of the larynx is about the same in both. The larynx of an average male is shorter than that of the average female, but it is broader and more inflated. The roof, also, extends proportionately farther forward. The narrow bar of cartilage (Pl. 8. figs. 1 and 3, *z*), which forms the hinder edge of the hyoglossal foramen in the female, is in the male partially replaced by ligament (Pl. 8. figs. 4, 5, and 6, *l*). This is a matter of the highest importance from a morphological point of view, for the substitution has the effect of severing the true basal plate of the hyobranchial skeleton from its lateral outgrowths in such a way as to make it appear part of the laryngeal skeleton. The basal plate, already so reduced in size, is now separated from all the rest of the hyobranchial skeleton, except the thyrohyals. In it Henle (19. p. 17) has described a hexagonal ossified plate, evidently a further development of the small centre of ossification occurring in the same position in the female. I must confess that in the specimens which I have had the opportunity of examining I have found no trace of ossification in this region. Whether my specimens were too young, or whether Henle's specimen was abnormal I cannot say,—the bony plate which he figures is so large in comparison with the remainder of the larynx that it is hardly likely that his observation is at fault.

The thyrohyals are slightly curved, although straight in the female; and, owing to the lateral expansion of the laryngeal skeleton proper, they appear to lie more on the ventral side of the larynx than in the female (see Pl. 8. figs. 1, 3, 4 and 6). It thus happens that they are not visible in a dorsal view of the skeleton, whereas in the female very little of the thyrohyal is overlapped by the cricoid cartilage (see Pl. 8. fig. 3). The floor of the

larynx of the male is complete *, the membranous spaces which occur between the anterior ends of the thyrohyals in the female being filled up by cartilage. The portion of the side-wall of the larynx situated externally to the arytenoids is much more massive in the male; and, whereas in the female the blinker-shaped process terminates anteriorly in an abrupt edge, it fuses in the male with the true basal plate of the hyobranchial skeleton (Pl. 8. fig. 6, *bl.*). The cricoid cartilage is very much thicker than in the female, and the thickening has proceeded irregularly into the interior of the larynx (Pl. 8. fig. 5) in a manner recalling the formation of the turbinal ingrowths of the nasal capsule in higher vertebrates. The general impression is one of solidity and massiveness, in striking contrast with the delicacy and elegance of the female larynx.

A comparison of median sections of the male and female larynx (Pl. 8. figs. 5 and 2) shows that most of the differences are those of degree and not of kind; but there is one most important structural dissimilarity to be noted. The posterior processes of the arytenoid cartilages of the male are confluent with one another (Pl. 8. fig. 6, *ar.'*). The union is brought about by a thin horizontal sheet of cartilage, situated immediately behind the glottis, and dorsal to the broad, flat, articular surfaces by which, as in the female, the two massive parts are applied to one another in the median plane (see fig. 5). The relations of the connecting cartilage are such as to warrant the assumption that there is here a procricoid cartilage, not free as in the female *Pipa* (Pl. 9. figs. 2 and 3, *pc.*), but united on either side with the arytenoids. This is certainly the most plausible explanation of the facts, but it involves the curious anomaly, that a procricoid cartilage is present in the male *Xenopus* and in the female *Pipa*, while no trace of it can be detected in the female *Xenopus* and in the male *Pipa*. The arytenoids proper (Pl. 8. figs. 5 and 6, *ar.*) stand nearly vertically, and do not slope downwards and outwards as in the female. Henle (p. 18) states that the arytenoids are ossified in the male, but this I am not in a position to confirm.

The bronchial cartilages are disposed just as in the female. The bronchi have long been known to be shorter in the male than in the female, but undue stress seems to have been laid on this fact in consequence of the failure to take into account the

* Wilder erroneously states it to be entirely membranous (42. p. 292, and Taf. 21. fig. 59).

smaller size of the body of the male. An extensive series of measurements shows that the proportion between the length of bronchus and the distance between the snout and cloaca is the same—one-seventh—in both sexes.

Hyobranchial Skeleton of *Pipa americana*, Female.

The first figures published of the hyobranchial skeleton of *Pipa* are those of Breyer (**4**). These figures, correct as far as they go, show, however, none of the details of the skeletal parts lying towards the median line. Mayer (**25**), in his monograph on *Pipa*, says very little about the hyobranchial skeleton, and gives no figures of it. It is in his paper on *Xenopus* (**26**. p. 31) that he mentions the absence in *Pipa* of the anterior or hyoidean cornua—a fact previously noticed by Meckel (**27**. p. 229). Henle's description and figure (**19**. Taf. 2. fig. 11) of the female are the first upon which any reliance can be placed. Henle agrees with Meckel and Mayer that the anterior cornua are reduced, and states (p. 16) that they are only represented by the pointed cartilage at the front of the hyobranchial skeleton. Parker (**33**. p. 651) was the first to show that the hyoidean cornua are present in the embryo. He does not figure the hyobranchial skeleton of the adult, but in the ripe young, just about to quit the maternal pouches (Pl. 60. fig. 7), this portion of the skeleton has already acquired most of the characters of the adult. A criticism of this figure will be found on page 110. The figure furnished by Grönberg (**18**. p. 636, fig. A. iii.), although only an outline text-figure, shows more accurately than any published previously the relations obtaining between the hyobranchial and the laryngeal skeleton in the female.

On comparing the hyobranchial skeleton of the female *Pipa* with that of *Xenopus*, one recognizes at once the large wings (Pl. **9**. fig. 1, *a*), the greatly reduced basal plate (*yx.*), and in front of it the large foramen (*h*) through which the hyoglossal muscles rise to be distributed to the mucous membrane of the floor of the tongueless mouth. The basal plate and the thyrohyals (*t*) have entered into the formation of the floor of the larynx; the bronchi are elongated and are supported by bronchial cartilages (*br.*). The hyobranchial skeleton terminates in front in a tapering rod of cartilage (*ch.'*), evidently the homologue of the rod-like cartilage (Pl. **8**. fig. 1. *ch.'*) which extends forwards in front of the hyoglossal foramen in *Xenopus*. The foramen is

more circular in *Pipa* than in *Xenopus*, but tends to become elliptical with increasing age. Even in very old specimens the antero-posterior diameter is not vastly in excess of the transverse, so that the hole is never so drawn out as in the middle-aged *Xenopus*. As in this latter genus, the anterior three-fourths of the foramen are closed by a fatty membranous tissue.

The antero-lateral processes of *Xenopus* (Pl. 8. fig. 1, *ap.*) are missing, and the wings are of an entirely different shape. The stalk of attachment to the axial parts of the hyobranchial skeleton is very narrow. The basal plate is much constricted a short distance behind the hyoglossal foramen so as to be divided into two parts connected by an isthmus (Pl. 9. fig. 1, *i*). The anterior portion forms the hinder border of the foramen, the posterior enters into the constitution of the floor of the larynx. It is from the posterior edge of the latter portion that the thyrohyals arise. Henle states (19. p. 16) that the isthmus is ligamentous as it is in the male; but Grönberg (18. p. 635) has already corrected this error. The hyobranchial skeleton of the old female differs in numerous particulars from that of the female just sexually mature. The foramen, as already pointed out, is elliptical instead of circular, the pointed cartilage in front is longer and thinner, the wings are more incised on their inner margin, while the stalks are narrower and more elongated. Breyer states (4. p. 14) that the "lamina" or wing of the hyobranchial skeleton of *Pipa* is longer and narrower in the male than in the female. Meckel (28. Theil iv. p. 338) agrees with Breyer that the wing of the female *Pipa* is broader than that of the male, but says it is longer also. Mayer (26. p. 32) affirms that the wing is especially broad and strong in the male. The difference in proportion is, however, in my opinion, one of age, not of sex.

Laryngeal Skeleton of *Pipa americana*.

The first mention of the larynx of *Pipa* was made in 1764, by Fermin, who describes it in the male as the lambdoid bone *;

* Fermin, 13. p. 150. "* * * deux cavités distinctes et séparées l'une de l'autre par un diaphragme, attaché à un Os triangulaire, qui a la forme d'un Ω grec, que l'on pourroit appeler l'os *Lambdoïde*. Il est situé au dedans de la cavité générale, ou sa base se trouve fixée par un fort ligament à la partie supérieure du *Sternum*; et duquel il déborde un peu. De la base du même Os sortent deux ligamens assez forts qui s'implantent dans la partie moyenne de la machoire inférieure."

and the first figures are those of Schneider (**37.** Tab. 2. figs. 4, 7–11). The specimen figured, a male, was in a bad state of preservation, and this it was in all probability which led Schneider into the mistake of regarding the larynx as a constituent of the sternal skeleton (**37.** pp. 261 and 263). The larynx of *Pipa* was first described in any detail by Breyer (**4**), who gives figures, rather poor, of both sexes. A much better description, referring principally to the male larynx, was furnished in 1825 by Mayer (**25**), but without figures. In his paper on *Xenopus*, ten years later, he gives a figure (**26.** Taf. 3. fig. 5) of the larynx of the male *Pipa*, broken open to show the elongated arytenoids lying within. The first figures showing the detailed structure of the larynx we owe therefore to Schneider and Mayer, and not to Henle as stated by Grönberg (**18.** p. 634), who appears not to have seen the 'Historia amphibiorum' nor Mayer's second contribution. Much valuable information is to be gathered from Henle's careful description and illustrations of the larynx of both sexes. The study of the larynx of *Pipa* was again undertaken by Grönberg in 1894, and the eight figures that he gives (**18.** Taf. 38. figs. 10–17) are excellent. He treats of both sexes, but chiefly of the male.

Female.

The larynx of the female *Pipa* is smaller in proportion to the size of the whole hyobranchial skeleton than in the *Xenopus* female. It is also relatively shorter in an antero-posterior direction, but the length increases with age. The only ossified parts are the thyrohyals (Pl. **9.** fig. 1, *t*), which are very much shorter, broader, and flatter than in *Xenopus*, and are situated in the floor of the larynx and not at the sides. Their anterior ends are nearly in contact, and the posterior epiphyses are indistinguishably fused with the postero-ventral band of the cricoid cartilage. The space between the bones themselves is closed by membrane, a fact which Grönberg in his excellent paper fails to notice, although Meckel (28. Theil vi. p. 451) and Henle (**19.** p. 19, and Taf. 2. fig. 11. *.) had already pointed it out. Breyer states that the ossified bars are absent in the young female. His figure (**4.** Tab. 2. fig. 5) of the adult female larynx he subscribes "Larynx femina a parte inferiore cum laminis osseis," but he most unfortunately locates the bones on the roof of the larynx in his text (p. 15), "lamina inferior mere cartilaginea est;

lamina superior pariter cartilaginea duo tamen exhibet ossicula plana," etc. This error was exposed by Meckel in 1833 (**28**. Theil vi. p. 451). It may be well to point out here that, while Henle describes the orientation of parts with the toad standing on its hind legs in an erect, human position, Breyer and most writers place the animal belly downwards. What, therefore, in this paper is called the roof of the larynx, is the 'lamina superior' of Breyer, the 'dorsale Wand' of Grönberg, and the 'hintere Wand' of Henle. Wilder (**42**) avoids the difficulty by speaking of the 'pharyngeal' and 'cardiac' surfaces.

The roofing cartilage of the larynx has a deep angular notch posteriorly and an approximately semicircular one anteriorly. The incisions are so deep that a median longitudinal section of the larynx shows only a very small extent of cartilage in the roof (Pl. **9**. fig. 3, *c*). Into the anterior space there fits a thin unpaired plate of cartilage, which overlaps the hinder portions of the arytenoids. This plate (figs. 2 and 3, *pc.*) is probably to be regarded as a dismembered part of the cricoid cartilage. Its nearest representative, Henle points out (**19**. p. 43), is the small cartilage similarly placed in some Chelonia, (see Henle, **19**. Taf. 5. figs. 28 and 29, *d*). Dubois (**9**. p. 181, and fig. 5) calls this latter the procricoid, and the name may safely be extended to the cartilage under consideration in *Pipa*.

The arytenoid cartilages are rather larger in proportion to the size of the larynx than in the female *Xenopus*, and the process (Pl. **9**. figs. 1 and 2, *d*) to which the tendon of the dilator muscle is attached extends outwards considerably beyond the outer margin of the thyrohyal; whereas in *Xenopus* the whole of the arytenoid is confined to the space between the two thyrohyals (*cf.* Pl. **9**. figs. 1 and 2, and Pl. **8**. fig. 3). The anterior parts supporting the sides of the glottis are thin; the posterior parts underlying the procricoid, although touching one another in the median line, are not massive as they are in *Xenopus*, nor do they articulate by broad flat surfaces. A median section of the larynx shows the existence of a firm fibrous mass (fig. 3, *vc.*) covered by a thin mucous membrane, and attached to the mesial surface of the arytenoid cartilage. Its posterior edge is free, and although the tissue is not as elastic as the vocal cord of tongued Anura, there can be little doubt that the two structures are homologous. It may be said of the male *Pipa* and of both sexes of *Xenopus*, that vocal cords are absent, but this statement should be

qualified in respect of the female *Pipa*. The median section also demonstrates the small extent of cartilage in the median line of the roof (fig. 3, *c*) and floor (*c''*) of the larynx. Owing to the close approximation of the anterior ends of the thyrohyals and the presence of the membranous space in the floor of the larynx there is less difficulty than in *Xenopus* in recognizing the morphological posterior edge of the basal plate of the hyobranchial skeleton (figs. 1 and 3, *x*). The fenestra seen in the side-wall of the larynx of *Xenopus* does not occur in *Pipa*.

The bronchi are elongated and are supported by bronchial cartilages. These cartilages have the form of independent bronchial rings, and are not, as they are in *Xenopus*, united into a band running lengthwise along the bronchus. The bronchial skeleton is also more complete in *Pipa*, the rings extending three quarters of the way round, while in *Xenopus* the lateral projections of the longitudinal bronchial cartilage do not extend more than halfway round. And, what is still more important, the bronchial rings of *Pipa* are incomplete on the mesial side, whereas in *Xenopus* it is the external wall of the bronchus that is not supported by cartilage.

Male.

The larynx of the male *Pipa* is unique and unparalleled not only among the Anura but in the whole animal kingdom. It is almost entirely ossified, and thus contrasts forcibly with the larynx of the male *Xenopus* which, although more massive and inflated than that of the female, is certainly not more bony. The larynx of the male *Pipa* is about twice as long as that of the female—five or six times so according to Mayer (25. p. 540), but this computation is excessive. It is proportionately broader in front, so that in a dorsal or ventral view it has roughly the form of a rectangular cushion or pillow. The floor is continued forwards into a pointed process of unossified cartilage, which is attached by ligament (Pl. 9. fig. 5, *i'*) to the middle of the transverse bar forming the posterior boundary of the hyoglossal foramen. The cartilaginous process at the front of the larynx and the bar bounding the back of the foramen are the posterior and anterior portions respectively of the basal plate of the hyobranchial skeleton. The ligament connecting them has the same morphological value as the cartilaginous isthmus of the female (Pl. 9. fig. 1, *i*). It must not be confounded with the paired

ligament (Pl. 8. fig. 6, *l*) of the larynx of the male *Xenopus*, although the physiological significance is probably the same. The ligament in *Pipa* connects the anterior and posterior portions of the basal plate, but in *Xenopus* the basal plate is not subdivided, but is incorporated bodily into the constitution of the larynx, while the ligaments arise from its anterior end. Except in the ligamentous nature of the isthmus the hyobranchial skeleton of the male *Pipa* does not differ materially from that of the female.

The laryngeal walls are remarkably complete; the roof (Pl. **9**. fig. 4) extends nearly as far forwards as the floor, and the notch in its posterior border is but slight. The floor has a small but deep notch behind (Pl. **9**. fig. 5) and, a short distance in front of the notch, a pair of small fenestræ; but beyond these it is one expanse of bone. The greater part of the floor is formed by the flattened thyrohyals, which can be distinguished from the rest of the bone by their yellower colour and closer texture. The two thyrohyals actually touch one another anteriorly, and the membranous area in the floor of the female larynx is here closed by a narrow strip of ossified cartilage. Along the sides of the larynx the junction of the cricoid and thyrohyal is marked by a very conspicuous groove (fig. 6). The roof of the larynx is marked by a cruciform area in which the ossification is less complete than elsewhere. Grönberg (**18**. Taf. 38. fig. 11) represents this in his figure as actually cartilaginous.

Although Grönberg was unable to consult Henle's treatise on the larynx, and had to remain content with the copies of the figures of that work published in Bronn's 'Klassen und Ordnungen' (**20**), he detected that Henle had confounded the dorsal and ventral surfaces of the larynx of the male *Pipa*. Curiously enough, Henle (**19**. p. 20 footnote) charges Breyer with doing exactly the same thing. "Rudolphi hat die hintere und vordere Fläche verwechselt." As a matter of fact, Breyer's description is correct and Henle himself was wrong. He had probably observed that Breyer had described the thyrohyals on the wrong surface of the female larynx, and became afterwards confused as to the sex for which the description was erroneous.

The two bronchi open together close to the median plane, by a pair of apertures which occupy only a small proportion of the posterior laryngeal wall. The bronchial cartilages are arranged as in the female. The bronchi of *Pipa* have since the

time of Breyer (4. p. 15) been known to be longer in the female than in the male, but the difference seems to have been much exaggerated. Grönberg (18. p. 638) puts the length of bronchus of the male at 15 to 20 mm., and that of the female at 25 mm., and my own measurements accord tolerably well with these.

The arytenoids are even more remarkable than the rest of the laryngeal skeleton. The glottis, which is small in proportion, is situated quite at the front of the pillow-shaped larynx. It is bounded by small arytenoid cartilages (Pl. 9. fig. 5, *ar.*) which are continued outwards and backwards as relatively huge bones (*ar.'*), each provided with four articular surfaces and two processes for muscle-attachment. The bulk of each bony mass has the form of a rod with a very irregular warty surface. The rods extend the full length of the laryngeal cavity: their posterior ends are bluntly pointed and lie over the bronchial apertures. They are composed of a very hard and brittle bone, and when broken across exhibit a central whiter and softer part. Their extreme length is about 22 or 23 millim. What renders these rods the more remarkable is the fact that there is not the least suggestion, anticipation, or foreshadowing of them in the female. The posterior parts of the arytenoids of the female *Pipa* are insignificant even when compared with those of the female *Xenopus*. Henle has already figured and described * with great minuteness the configuration of these bones, so that it will here suffice to state that they articulate with one another by two pairs of processes, one towards the dorsal and the other towards the ventral side, and that each articulates by a large flat surface with the roof (figs. 4 and 5, *v*), and by a ball-and-socket joint with the floor of the larynx. As a consequence of these peculiarities of articulation the rods lie close up to the roof, and are raised somewhat above the floor. The fibrous tissue which occupies the position of the vocal cords is less conspicuous than in the female, but the arytenoid cartilages are distinctly hollowed out, and are thickened along those edges that bound the glottis. Although there is a very sharp line of demarcation between the cartilage and bone, the two are perfectly continuous and move

* In referring to Henle's description it must not be forgotten that he had confounded the dorsal and ventral surfaces, and that in his figures (19. Taf. 2. figs. 16–20) the words 'vorn' and 'hinten' must be transposed throughout. In Mayer's earlier work (25. p. 541), where a less detailed description is given, the orientation of parts is correct.

together. I fail to see what advantage is to be gained by giving distinct names to the cartilaginous and ossified portions as Grönberg does (**18.** p. 636).

The hinging of the rods is such that they can swing in the horizontal plane, and the free posterior ends are capable of moving through a distance of about 3·5 millim. each. The hinder parts of the rods can touch one another in the median plane, as may be seen by manipulation, and more conclusively by the flatness of the more projecting parts of their mesial surfaces, where the impact, of which more anon, normally takes place. They are, however, prevented from crossing the middle line by a forwardly directed process of cartilage (Pl. **9.** fig. 5, *cr.*) standing up from the inner surface of the posterior part of the floor of the larynx. A similar crest, of much smaller size, hangs down from the roof. The two rods are notched internally, so that they can strike one another without encountering these crests. The rods are actuated by special dilator muscles attached to outstanding processes (Pl. **9.** fig. 5, *d*) of the parts situated anteriorly to the centre of oscillation (*v*). On the contraction of the muscles the anterior parts of the rods are divaricated, and the longer posterior portions are brought into contact.

Although Müller (**30.** p. 222) has compared the rods with the two prongs of a tuning-fork, most authorities liken them to the clapper of a bell. Mayer, for instance, states (**25.** p. 542) that they are disposed in such a manner, "dass sie an die innere Wandung der Höhle desselben, wie der Schwengel in der Glocke, anschlagen können." Henle erroneously regarded the bones as fixed in position and unable to swing bodily to and fro, and concluded (**19.** p. 31) that the sound uttered must be due to molecular vibration. Grönberg (**18.** p. 637) exposed the fallacy of this statement and showed that, although the rods do not swing about fortuitously at every movement of the animal, they are nevertheless capable of motion, and that they are controlled by special muscles attached to them. A study of the muscular mechanism has convinced me that the rods do not beat against the laryngeal walls as a clapper strikes a bell, but that they strike one another in the manner indicated above. It is evident that the larynx is thus curiously modified for the production of sound, and the sound to be expected on *a priori* reasoning is a series of short, sharp taps caused by the impact of the rods, following one another as quickly as successive contractions of

the muscles can be effected,—a sound similar to, though probably more rapidly repeated than, the taps given by certain wood-boring beetles.

Having arrived at this conclusion, it was most gratifying to me to hear Mr. Arthur Thompson, when recounting at a recent meeting of the Zoological Society his observations on the habits of the Surinam toads then breeding in the Society's menagerie, mention, quite incidentally, the rapping noise which they made. All those anatomists who have paid any attention to the subject have remarked on the failure of anyone to hear the sound, which they were convinced must emanate from such a complicated laryngeal apparatus. Grönberg, in his recent contribution, says (18. p. 637) " es würde von grossem Interesse sein, zu erfahren, ob *Pipa* wirklich eine diesem Apparat entsprechende Stimme hat. Mein Freund, Freiherr A. von Klinckowström, der lebende Wabenkröten in Surinam oftmals beobachtet hat, will niemals einen Laut von ihnen gehört haben." And even in the current year Wilder writes (42. p. 291) that the matter " is deserving of careful investigation from the side of the physicist, as well as that of the naturalist." Mr. Thompson's remarks were therefore most opportune.

On further inquiry I gathered that the sounds were heard by many visitors to the Society's Gardens, who variously described them as resembling the tapping of a key on the glass of the tank in which the animals lived, the striking of two chisels together, and the distant sound of a bricklayer's trowel. All were agreed that there is a metallic ring about the sound, and that two, three, or four taps follow one another in quick succession,—then, after a pause there comes a repetition, and so on throughout the day and night. There is at present insufficient evidence that the noise is an accompaniment of the amatory overtures, but it is worthy of remark that these animals were mute before the breeding period, and have since relapsed into silence. Mr. Thompson stated it as his firm belief that both sexes shared in the clamour and that their voices were indistinguishable; but, personally, I fail to see how such a tapping sound could possibly emanate from the female larynx, where there is no backward growth, enlargement nor ossification of the arytenoids.

At this same meeting of the Zoological Society Mr. G. A. Boulenger, F.R.S., stated that the *Xenopus* during the breeding period utters a sound which he compared with that produced by

pushing the wet finger across a pane of glass. On referring to the structure of the larynx, it is evident that the sound must be produced by the vibration of the arytenoid cartilages or the edges of the glottis, since there are no vocal cords. Judging by the similarity in the shape of the arytenoids in the two sexes, it is probable that there is but little difference in the voices of the male and female.

Laryngeal Muscles of *Xenopus lævis*.

In view of the fact that the laryngeal skeleton is so dissimilar in the male and female of the two genera of the Anura Aglossa, it is not surprising that the muscles in relation with it should also differ in a remarkable degree. The following pages contain an account of the laryngeal muscles of both sexes of *Xenopus* and of the female *Pipa*. The specimens of male *Pipa* at my disposal were all unsuited for an examination of the muscular system, but I regret this the less as, thanks to Grönberg, our information on the laryngeal muscles of the male *Pipa* is not deficient. The object of this portion of the investigation was not only one of correlation of the various muscle-masses occurring in the two sexes of the same species, and of comparison of the muscles of *Pipa* with those of *Xenopus* and the tongued Anura, but of the search after additional evidence of the homology existing between the parts of the laryngeal complex of the two aglossal forms and those of the hyobranchial and laryngeal skeleton of more normal batrachians. As has already been pointed out by Henle (**19.** p. 21), muscles running normally from the hyobranchial skeleton to the larynx become in *Xenopus* and *Pipa* intrinsic laryngeal muscles, owing to the annexation by the larynx of a part of the hyobranchial skeleton. And some of the trunk muscles attached in other Anura to the hyobranchial skeleton here become extrinsic laryngeals.

The first account of the laryngeal muscles of *Xenopus* we owe to Mayer (**26.** p. 30). His description, which refers to the male, is unaccompanied by illustrations. Henle followed, four years later, with observations on the female, giving figures of the intrinsic muscles of the larynx. Beddard has recently described the muscular anatomy of both *Pipa* (**1**) and *Xenopus* (**2**) in greater detail than had been done previously; but he does not allude to the laryngeal muscles of either genus. The information furnished recently by Wilder concerning the laryngeal muscles of *Xenopus*

is of a very fragmentary and unreliable character, but he excuses himself (**42**. p. 309) on the ground that his only material consisted of a series of sketches drawn from a specimen dissected several years before. His figures (**42**. Taf. 21. figs. 58 and 61) are presumably reproductions of these sketches.

Female.

Dilator laryngis (Pl. **10**. fig. 2, *d*).—This dilator muscle of the glottis, called by Henle (**19**. p. 27 and Taf. 2. fig. 5, *m*) the "unterer Erweiterer," arises from the external and dorsal surfaces of the posterior three-fourths of the thyrohyal, and partly also from the roof of the larynx. None of the fibres arise from the floor; a point of some importance when considering sexual differences. The anterior end of the muscle runs into an extensive aponeurosis, the fibres of which pass directly inwards, in a direction transverse to the long axis of the larynx, and, after passing over the 'blinker-shaped' process of the laryngeal cartilage (Pl. **8**. fig. 3, *bl.*), are inserted into the dorso-external edge of the massive posterior enlargements (*ar.'*) of the arytenoid cartilage, and into the posterior part of the arytenoid (*ar*). guarding the glottis. The anterior part of the insertion of this muscle is not tendinous. No great difficulty besets the determination of this muscle, for, since it runs from the hinder part of the thyrohyal to the outer surface of the arytenoid, it evidently corresponds with the dilator laryngis * of other Anura.

The part of the muscle that arises from the roof of the larynx (Pl. **10**. fig. 2, *d'*) also spreads on to the thyrohyal, beneath the greater belly of the dilator. It is separable from the latter, and its tendon, which is about as long as the muscle itself, passes along the dorso-internal border of the thyrohyal, and, running in a groove between the roof and side of the larynx proper as around a pulley, is attached to the postero-externo-dorsal corner of the arytenoid enlargement. The relations are not such as to warrant the recognition of this as a distinct muscle. That the dilator muscle should spread from the thyrohyal inwards on to the roof of the larynx is not exceptional, for in the frog a few of the fibres of this muscle arise from the cricoid cartilage

* Dilatateur, Saint-Ange, **36**. p. 421, and Pl. 26. fig. 3', *d'*.
Hyo-ex-glottique, Dugès, **10**. p. 126, and Pl. vii. (bis), fig. 47, no. 26.
Oeffner des Stimmladeneingangs, Henle, **19**. p. 23.
Dilatator laryngis, Ecker, **12**. p. 315, and Göppert, **16**. p. 63.

(see **12**. p. 313). Wilder figures in *Rana clamitans* (**42**. Taf. 20. fig. 32, *t'*) an accessory slip of the dilator arising from the laryngeal cartilage instead of the thyrohyal, an exact counterpart of this slip in *Xenopus*.

Dilator laryngis anterior (Pl. **10**. fig. 2, *d.a.*).—This muscle, the "oberer Erweiterer" of Henle (**19**. p. 27, and Taf. 2. fig. 5, *m'*), arises from the external surface of the anterior part of the thyrohyal and extends over rather less than one half its length. It is inserted into the dorso-external surface of the arytenoid cartilage, in a line passing obliquely across the compressor muscle (*c*), which is peculiarly modified in consequence. No sharp line of separation can be distinguished between this muscle and the dilator just described, with which its fibres form a continuous series. So far as can be made out, the junction is oblique, the hinder part of the dilator anterior overlapping the front part of the dilator. Both muscles run from the thyrohyal to the arytenoid, and the insertion of the dilator anterior is in a continuous line with that of the larger muscle (see the dotted line on the left side of fig. 2, Pl. **10**). The fibres of the two muscles commingle externally as they arise from the thyrohyal, so that were it not for the greater distinctness and more marked individuality of the muscle under consideration in the male *Xenopus* and in the female *Pipa*, there would not be sufficient evidence to justify the conception of it as a separate muscle worthy of a distinctive name. It is a muscle which has arisen in all probability by the separation of the anterior part of the normal dilator laryngis, and may therefore be designated the " dilator laryngis anterior."

The only other determination which is at all plausible is that it represents the " constrictor " muscle * of other Anura, which has shifted back along the side of the glottis instead of uniting with its fellow of the opposite side in front. The constrictor normally arises from the thyrohyal and runs on the anterior side

* Hyo-pré-glottique, Dugès, **10**. p. 126, and Pl. vii. (bis), fig. 47, no. 25.
Verengerer des Aditus laryngis, Henle, **19**. p. 24 and Constrictor, **19**. Taf. i. fig. 42, *n*.
Constrictor aditus laryngis, Ecker, **12**. p. 315.
Peri-arytenoideus ventralis, Wilder, **41**.
Hyo-laryngeus, Göppert, **16**. p. 63.
Constrictor laryngis, Wilder, **42**. Taf. 20. fig. 31, *cs*.

Saint-Ange (**36**) does not distinguish between the constrictor and the dilator. He calls them both "dilatateurs" (p. 421), and marks them *d* and *d'* in fig. 3', Pl. 26.

of the dilator. If this suggestion be rejected the constrictor muscle is not represented in *Xenopus* *.

Compressor glottidis (Pl. **10**. fig. 2, *c*).—Lying on the right and left sides of the glottis and extending a short distance behind it is a muscle which I take to represent the compressor glottidis † of the frog, combined in all probability with the outer or posterior compressor ‡.

Henle calls it the "Compressor der Stimmlade" (**19**. p. 27, and Taf. 2. fig. 5, *p*). In front it is attached, close to the median line, to the upper surface of the basal plate of the hyobranchial skeleton at a short distance behind its anterior border (Pl. **8**. fig. 1, *y*). The muscle passes directly backwards, external to the arytenoid, and unites, behind the glottis, with its fellow of the opposite side in a linea alba, some of the fibres being inserted directly into the glottidean portion of the arytenoid cartilage just at its junction with the massive posterior enlargement. A broad sheet of fibrous tissue extends back from the hind end of the muscles and linea alba to be inserted into the front edge of roofing cartilage of the larynx. It is probably to be regarded as an aponeurotic extension of the muscle itself. The indirect connexion thus established between the muscle and the cricoid cartilage is not without parallel, for Göppert states (**16**. p. 63) that in the common frog some of the fibres of the external

* Henle definitely states (**19**. p. 26) that the constrictor is absent in *Pipa*: he makes no mention of it in *Xenopus*. The constrictor is absent in *Bombinator* (Henle, **19**. p. 24, and Wilder, **42**. Taf. 21. figs. 46 and 47), a fact of some importance considering how closely the hyobranchial and laryngeal skeleton of this toad resembles that of *Xenopus*. Wilder has remarked its presence in *Alytes*, and notes that it occupies an exceptionally ventral (cardiac) position. Grönberg has recorded its occurrence in the male *Pipa*, but concerning this see pp. 90 and 91.

† Compressor, Henle, **19**, p. 24, and Taf. i. fig. 42, *p′*.
Hoher, medianwärts liegender Constrictor, Ecker, **11**. fig. 14, *Co.l.*
Hyo-arytenoideus anterior, Ecker, **12**. p. 315, and fig. 205, *Co.l.*
Sphincter anterior, Göppert, **16**. p. 63.
Compressor laryngis, Wilder, **42**. Taf. 20. fig. 31, *cp.*

‡ Compressor, Henle, **19**. p. 24, and Taf. i. fig. 42, *p″*.
Tiefer constrictor laryngis, Ecker, **11**. fig. 14, *Co.l′.*
Hyo-arytenoideus posterior, Ecker, **12**. p. 315, and fig. 205, *Co.l′.*
Sphincter posterior, Göppert, **16**. p. 63.
Sphincter dorsalis, Wilder, **42**. Taf. 20. fig. 31, *sf.d.*

Dugès does not discriminate between the two muscles, but applies the term hyo-post-glottique to both, **10**. p. 126, and Pl. vii. (bis), fig. 47, no. 27.

Saint-Ange calls them both constricteurs, **36**. p. 421, and Pl. 26. figs. 3′, 4′ and 5′, *c* and *c′*.

division of the compressor (his "sphincter posterior") arise from the cricoid cartilage, a fact which Henle had previously recorded (**19**. p. 24) but in a somewhat unsatisfactory manner.

The middle of the compressor muscle is tendinous and closely bound to the external face of the arytenoid over a narrow area extending backwards and outwards from the middle of the length of the glottis. While the dilator anterior muscle is to all intents and purposes connected with the arytenoid cartilage, it would be more correct to say that it is inserted into the tendinous middle tract of the compressor, which in its turn is bound to the arytenoid. For, when the compressor is removed bodily from the skeletal parts, the dilator anterior muscle is found to be still very tightly bound to it, showing that the fibres do not simply decussate. The same treatment also shows that the two bellies, anterior and posterior, of the compressor cannot well be regarded as distinct muscles. Under any circumstances, they cannot be individually homologous with the two muscles running alongside the glottis in the frog, although the digastric compressor of *Xenopus* is probably equivalent to the two muscles of the frog taken collectively.

The muscles in the immediate vicinity of the glottis in Anura are subject to extreme variation, even in genera which are admitted to be closely allied. Henle made a comparative study of these muscles, and Wilder has latterly reconsidered the subject. Wilder acknowledges that the study is a most confusing one; but he has arrived at the conclusion (**42**. p. 308 *et seq.*) that the primitive periglottidean muscle in Anura is a sphincter surrounding the arytenoid cartilages and unconnected with the thyrohyals. The muscle may remain as such unchanged (*Bombinator**), or part of it may become differentiated into a compressor and a constrictor, while part remains as a sphincter (*Rana*); or the entire muscle may differentiate into compressor and constrictor (*Bufo*). The compressor and constrictor both acquire a secondary connexion with the thyrohyal. Of *Xenopus* he says (**42**. p. 313), "The sphincter in *Dactylethra* appears very simple, divided into four quarters by median and lateral raphés," and he notices that the "lateral raphés appear to be connected with the

* Henle is in error in describing (**19**. p. 24) a connexion between the compressor muscle and the hyobranchial skeleton in *Bombinator* and *Discoglossus*. I have examined the muscle in these genera and find it to be an intrinsic laryngeal in both.

method of insertion of the Dilatator." He fails, however, to note that the anterior ends of the sphincter muscles are attached, not to the arytenoid cartilages or one to another, but to the portion of the hyobranchial cartilage between the anterior ends of the thyrohyal bones. This fact leads me to think that the periglottidean muscles of *Xenopus* are not so simple as he makes out, and that they do not represent an undifferentiated sphincter such as occurs in *Bombinator*. Wilder says (**42**. p. 307) that in a late larval stage of the tadpole of *Rana* the as yet undivided sphincter attaches itself to the inner edges of the two thyroid processes. This occurs before the constrictor and compressor have been differentiated, and it is just this stage of development which, I take it, persists in *Xenopus*. The periglottidean muscle of *Xenopus* may therefore be regarded as including an undifferentiated constrictor; and the absence of any muscle which can with certainty be regarded as the constrictor laryngis lends support to the view.

Hyoglossus.—Turning now to the ventral aspect of the larynx, three important muscles are to be noted:—the hyoglossus, the geniohyoideus internus, and the petrohyoideus. The hyoglossus (Hyoglossus, Henle, **19**. p. 26) consists of three separate bellies, the external of which (hyoglossus externus, Pl. **10**. fig. 1, *h.e.*) arises from the ventral surface of the thyrohyal at about the middle of its length; while the middle division,—which Henle (**19**. p. 26) erroneously declares to be absent in *Xenopus*, although he mentions it as occurring in *Pipa*,—takes its origin from the floor of the larynx at about one-third of the length from the anterior end (fig. 1, *h.i.*). Mayer (**26**. p. 30) calls the hyoglossa muscle of Anura the ceratoglossus, and states that it appears to be wanting in *Xenopus*,—clearly an error of observation. He considers it equivalent to the muscle which he had previously called the laryngoglossus in *Pipa* (**25**. p. 537, and fig. 2, *e*).

The middle division of the muscle, the hyoglossus internus, is really double, and the two halves are at their origin perfectly distinct. But anteriorly they unite in the median plane, and at the front of the larynx they are inseparable. The external divisions arising from the thyrohyals, although closely applied to the internal division, do not fuse with it. The three muscle-trunks, after running forward ventral to the laryngeal cartilage and dorsal to the m. geniohyoideus internus (Pl. **10**. fig. 1, *g.i.*), are still readily separable as they pass upward, immediately in

front of the basal plate, to be distributed to the mucous membrane occupying the position of the lost tongue. It is on the relations of its anterior end that we have to rely for an identification of this muscle as the hyoglossal, for the origin posteriorly is quite exceptional. The hyoglossus in tongued Anura arises from the posterior extremity of the thyrohyal. In *Xenopus*, therefore, the muscle has undergone considerable diminution in length, arising as it does from the middle of the length of the bone. The hyoglossus internus is not represented in other Anura, and it is all the more curious to note that in the male *Xenopus* the normal external trunks have disappeared, leaving only this exceptional median portion.

Petrohyoideus (Pl. **10.** fig. 1, *p*).—Arising from the posterior part of the ventral surface of the larynx close to the median line, and running out sideways, is a peculiar muscle which represents the petrohyoideus of more familiar Anura *. It occurs in both sexes of *Xenopus*, in the female *Pipa*, and probably also in the male. Mayer and Henle are silent concerning it: in fact, throughout the whole of the literature on *Pipa* and *Xenopus* that I have examined, I have met with no reference to such a muscle. The muscle spreads beneath the ventral surface of the larynx in a fan-like manner, breaking up into small bundles of fibres which alternate more or less regularly on the right and left sides. The number of radiating bundles is subject to considerable variation, in some specimens being as small as three, while in one larynx examined as many as seven distinct divisions could be recognized on one side and six on the other. The muscle passes out sideways, ventral to the geniohyoideus internus, and diminishes considerably in width. Then, remaining of the same diameter for the rest of its length, it takes a circuitous course and is ultimately attached to the back of the auditory region of the skull. There is, I think, sufficient evidence here for identifying the muscle with one of the posterior petrohyoids of the frog, most probably the third or fourth of those described by Ecker (**12**).

Geniohyoideus.—The geniohyoideus has already been described by Henle (**19.** p. 26) as double in *Xenopus*. The outer division, geniohyoideus externus, arises from the mandible a short distance from the symphysis, and is inserted into the ventral surface of

* Masto-hyoïdien, Dugès, **10.** p. 125, and Pl. vii bis, fig. 44, nos. 20, 21, 22.
Stylohyoideus, Walter, **40.** p. 36.
Petrohyoideus, Ecker, **12.** p. 66, and figs. 60, 61, and 205, *p.h.*

the ala of the hyobranchial skeleton, at about the level of the anterior ends of the thyrohyals, in the position marked *g.e.* in fig. 1, Pl. **8**. This external geniohyoid of *Xenopus* is called by Mayer (**26**. p. 30) the genioceratoideus, but he considers it homologous with the muscle which he had previously named the geniohyoideus in *Pipa* (**25**. p. 538). The geniohyoideus internus (Pl. **10**. fig. 1, *g.i.*) (geniohyoideus of Mayer, **26**. p. 30) is attached by its anterior extremity to the mandible, nearer to the symphysis than the externus, runs parallel with the latter and extends backwards below the larynx to be inserted into the ventral surface of the posterior epiphysis of the thyrohyal. It runs ventral to the hyoglossus, but dorsal to the petrohyoideus. The two internal geniohyoid muscles are in close contact with one another for the greater part of their length, but they diverge somewhat posteriorly. In the frog, the geniohyoideus has a single belly in front and divides posteriorly into two parts. The internal of these (geniohyoideus medialis of Walter, **40**. p. 32) is attached to the inner border of the anterior end of the thyrohyal, and the outer (g. lateralis of Walter, **40**. p. 33) to the hinder of the two lateral cartilaginous processes of the body of the hyoid. If we admit that these two divisions of the muscle correspond with the geniohyoideus internus and externus respectively of *Xenopus*, a perfectly legitimate supposition, we must not fail to notice that the internal division is attached in *Xenopus* to the posterior epiphysis of the thyrohyal, but in the frog to the anterior end of that bone.

Obliquus internus.—The anterior end of the internal oblique muscle, though inserted mainly into the ventral surface of the great wing of the hyobranchial skeleton, sends a small slip with tendinous extremity to the posterior end of the thyrohyal (Pl. **10**. fig. 2, *o.i.*). The incorporation of the thyrohyal into the laryngeal complex of *Xenopus* demands that this slip should be regarded as a laryngeal muscle, and a passing notice is therefore here accorded to it.

Male.

In considering the muscles of the male *Xenopus*, it will be sufficient to note only those points in which they differ from the muscles of the female. The same seven muscles are in relation with the larynx, although they are very much modified in form. The trend of such modification is not in one uniform direction, for, while the dilator muscles are excessively enlarged as compared with those of the female, the geniohyoideus internus, the

petrohyoideus, and the hyoglossus are considerably reduced. The most remarkable feature is, without doubt, the extensive development of the *dilator* (Pl. **10.** figs. 3 & 4, *d*). This muscle covers the whole of the sides of the laryngeal complex, nearly the whole of the ventral surface, and a considerable portion of the dorsal. It is distinctly differentiated into a superficial and a deeper layer (*d* and *d'*), and the tendon of the latter passes forward and inward in the pulley-like groove at the side of the roof of the larynx, and is inserted into the dorso-external border of the posterior massive part of the arytenoid. The aponeurosis that passes over the blinker-shaped process of the laryngeal cartilage is very delicate, far more so than in the female. The dilator muscle in the female extends round the outer border of the thyrohyal and very slightly, if at all, on to its ventral surface; but in the male the belly of the muscle has spread so as to cover the whole of the ossified part of the thyrohyal and to meet its fellow of the opposite side in the ventral median line (see Pl. **10.** fig. 3). The only parts of the ventral surface of the larynx over which the muscle does not extend are, first, a small triangular area in front occupied by the hyoglossus, and, secondly, a larger space, also triangular, at the posterior end between the petrohyoids.

The *dilator anterior* (Pl. **10.** fig. 4, *d.a.*) is better differentiated from the dilator than in the female, although relatively shorter and smaller in bulk. Its fibres are inserted into the arytenoid cartilage over the anterior two-thirds of the side of the glottis. They pass outward and downward, but very slightly backward, and spread out in the form of an aponeurosis over the ventral surface of the anterior part of the dilator. Wilder (42. Taf. 21. fig. 61, *t*) identifies this muscle as the "dilatator laryngis." He describes it, however, as arising from the thyrohyals, an origin peculiar to the female; and I cannot help thinking that he was mistaken in the sex of the animal he examined. The *hyoglossus* (Pl. **10.** fig. 3, *h.i.*) is much more feebly developed than in the female, and although the relations of the anterior end are the same, the posterior extremity does not reach nearly so far back. In the female the outer fibres arise from the thyrohyals, but in the male the whole of the muscle arises from the cartilage of the laryngeal floor. The reduced hyoglossus thus probably corresponds with the median belly only (hyoglossus internus) of the muscle in the female. The *geniohyoideus internus* (Pl. **10.** fig. 3, *g.i.*) is more

slender than in the female, but exhibits, even in a more marked degree, the same diminution in width in that part of its length which underlies the anterior end of the larynx. It runs dorsally to the petrohyoideus as in the female, but is separated from the cartilaginous floor of the larynx by the intruded sheet of the dilator.

The *petrohyoideus* (Pl. **10**. fig. 3, *p*) is also more feebly developed than in the female. Only the anterior fibres reach the median line, so that a triangular space of bare cartilage is left between the hinder parts of the expanded laryngeal extremities of the muscle. The radiation of the fibres is much more uniform and regular than in the female. The *compressor glottidis* (Pl. **10**. fig. 4, *c*) does not differ materially from that of the female. Many of the fibres are distinctly attached to the arytenoid cartilage posteriorly, and the connexion of the muscle with the fascia-sheet covering the dorsal surface of the arytenoid plate (Pl. **8**. fig. 6, *ar.'*) is comparatively unimportant. Owing to the feebleness of the anterior dilator, the anterior and posterior bellies of the compressor are less distinct than in the female, and, when the muscle is isolated and examined under the microscope, muscle-fibres can be seen passing from one belly to the other. In the female, the intervening part is wholly tendinous.

Laryngeal Muscles of *Pipa americana*.

The first description of the hyobranchial and laryngeal muscles of *Pipa* we owe to Mayer (**25**), who includes them in his chapter on the general muscular anatomy of the female. Meckel (**28**) paid some attention to the subject, as also did Henle (**19**). Henle's description applies to the female sex *, and is well illustrated. More recently, Grönberg (**18**. pp. 637 and 638) has resumed the study of the subject, but his remarks refer exclusively to the intrinsic muscles of the male larynx. His figures (Taf. 38. figs. 18–20) are, however, most valuable, being the only illustrations extant of the laryngeal muscles of that sex.

Female.

The muscles in relation with the larynx in the female *Pipa* resemble in the main those of *Xenopus*. The same arguments, therefore, which have previously been adduced for determining

* Not male, as stated by Grönberg (**18**. p. 637).

the homologies of the muscles of *Xenopus* with those of other Anura will apply in the present case, and need not be repeated. The most important feature in which the laryngeal musculature of *Pipa* differs from that of *Xenopus* is in the absence of the geniohyoideus internus. Arising from the roof of the larynx in the elliptical area marked *a* in fig. 5, Pl. **10**, is a very loose tissue, mainly connective tissue, but containing numerous scattered muscle-fibres which are inserted into the mucous membrane of the pharynx behind the glottis. No particular direction can be ascribed to the fibres, for they cross one another in a most irregular manner. Radiating outwards and backwards from the postero-external border of the same area are a few muscle-fibres arranged in the form of a thin sheet, attached distally to the internal concave edge of the great wing of the hyobranchial skeleton. Neither of these tracts appears to be of sufficient importance to warrant the application of a distinctive name.

The *dilator laryngis* (Pl. **10**. figs. 5 & 6, *d*) [Laryngeus proprius, Mayer, **25**. p. 538; Dilatator aditus laryngis, or Erweiterer, Henle, **19**. p. 26, and Taf. 2. figs. 14, 15, & 23, *m*] arises from the postero-external border of the laryngeal complex, and, considering the large size of the muscle, its posterior attachment is remarkably small. It occurs partly on the dorsal and partly on the ventral surface of the larynx. Its belly is large and well defined, and narrows considerably anteriorly, and it is inserted by a small tendinous extremity into the most external part of the lateral promontory of the arytenoid cartilage (Pl. **9**. fig. 2, *d*). The *dilator laryngis anterior* (Pl. **10**. fig. 5, *d.a.*) is very clearly distinguishable from the dilator. It arises from the fascia of the external surface of the anterior part of the latter muscle, passes upwards, forwards, and inwards, and gradually diminishes in width. It runs dorsal to the compressor (*c*) and is inserted into the edge of the arytenoid cartilage guarding the side of the glottis. A few of the fibres, also, are attached indirectly to the arytenoid cartilage by being inserted into the aponeurosis between the anterior and posterior bellies of the compressor.

Compressor glottidis (Pl. **10**. fig. 5, *c*) [Compressor laryngis, Henle, **19**. Taf. 2. figs. 14, 15, *p*].—The anterior and posterior bellies of this muscle are very sharply differentiated, and the aponeurosis between the two extends obliquely backwards and outwards, exactly as in *Xenopus*. The aponeurosis is attached by its ventral surface to the anterior edge of the lateral pro-

montory of the arytenoid, and by its dorsal surface to some of the fibres of the dilator anterior. Posteriorly, the compressor muscles of the right and left sides unite, immediately behind the glottis, in a linea alba which extends backwards for a distance equal to the width of each muscle. The anterior extremity of the compressor is attached to the lateral edges of the median isthmus of cartilage (Pl. **9**. fig. 1, *i*) which connects the part of the hyobranchial cartilage bounding the hyoglossal foramen with that which forms the anterior end of the laryngeal complex. In this respect the compressor differs from that of *Xenopus*, for in this latter genus the attachment of the anterior end of the muscle is to the dorsal surface of the equivalent cartilage.

The *hyoglossus* [Laryngoglossus, Mayer, **25**. p. 537 and fig. 2, *e*; Rückwärtszieher der Zunge, Meckel, **28**. Theil iv. p. 340; Hyoglossus, Henle, **19**. Taf. 2. figs. 22 and 23, *4*] is a much longer muscle than that of *Xenopus*, and extends nearly the full length of the larynx. The external and internal divisions also are better differentiated. The hyoglossus internus (Pl. **10**. fig. 6, *h.i.*) arises from the ventral surface of the larynx near the posterior end, and the area of attachment slopes obliquely backwards and outwards. The muscle crosses dorsally to the petrohyoideus and runs forwards beneath the larynx, diminishing at the same time in width. The internal hyoglossals of the right and left sides converge anteriorly; they fuse together, pass through the median foramen in the hyobranchial skeleton, and spread out as a single muscle (Pl. **10**. fig. 5, *h.i.*). This is inserted into that part of the mucous membrane of the floor of the mouth which lies over the beak or point of the hyobranchial skeleton (Pl. **9**. fig. 1, *ch.'*). The external hyoglossus (Pl. **10**. fig. 6, *h.e.*) is in the main slightly broader than the internal, but its posterior area of attachment is smaller than, and lies posteriorly to, that of the latter. The two muscles, internal and external, thus overlap one another at their posterior ends, but they separate out anteriorly. The external trunks occupy a lateral position with regard to the internal as they pass through the hyoglossal foramen. Then, instead of continuing forwards, they turn sharply outwards at right angles to their former course (Pl. **10**. fig. 5, *h.e.*), the left to the left and the right to the right. They spread out and become inserted into the mucous membrane of the lateral parts of the floor of the mouth. Henle (**19**. p. 25) mentions the three muscles spreading out in the floor of the mouth, but he fails to note the

quadruple nature of the hyoglossal muscle posteriorly. He also states (p. 77) with Mayer (**25**, p. 537) that the external hyoglossus arises from the thyrohyal or columella. Careful dissection, however, shows that the origin is internal to the cartilage which is to be regarded as the epiphysis of the thyrohyal.

The *petrohyoideus* (Pl. **10**. fig. 6, *p*) arises from the membranous ventral wall of the larynx, close to the median line, at about one-third of the length from the posterior end. It extends outwards and backwards, coils round the external edge of the great wing of the hyobranchial skeleton, and, passing forwards and upwards, is attached to the dorso-external crest of the auditory capsule, close beside the inner end of the columella auris. It runs ventral to the hyoglossus and the geniohyoideus externus, but dorsal to the obliquus internus. It is a very long and meandering muscle, and is of uniform width all along, except at its laryngeal extremity. It is relatively smaller than in the female *Xenopus*.

Geniohyoideus (Mayer, **25**. p. 538; Henle, **19**. Taf. 2. figs. 22 and 23, *3*).—Henle (p. 26) has already noted that the inner division of the geniohyoideus, attached to the laryngeal skeleton in *Xenopus*, is absent in *Pipa*. The external division is a long, slender muscle, of even diameter, extending from the symphysial region of the mandible to the postero-external region of the ventral surface of the great hyobranchial ala. The position of its insertion is shown at *ge*. in fig. 1, Pl. **9**. The recognition of this muscle in the embryo is a matter of no great difficulty, and as soon as the wing of the hyobranchial skeleton is clearly differentiated from the neighbouring parts, the insertion of the muscle is seen to be related to it exactly as in the adult (see Pl. **11**. fig. 8, *ge*.). Seeing that the wing is purely a derivative of the hypobranchial plate of the larval skeleton, it would be more satisfactory to substitute for geniohyoideus the word geniohypobranchialis, the name by which Schulze (**38**) designates this muscle in his treatise on the development of *Pelobates*. It is worthy of remark that, while in *Pipa* the geniohyoideus externus is attached to the ala near its posterior edge, the position of the insertion of this muscle in *Xenopus* lies in front of the line joining the anterior extremities of the thyrohyals (see *ge*. Pl. **8**. fig. 1 and Pl. **9**. fig. 1).

Obliquus internus (Pl. **10**. fig. 5, *o.i.*).—In the larynx of the young but sexually mature female depicted in fig. 5, Pl. **10**, the laryngeal division of the internal oblique muscle is of consider-

able size. It partially overlaps the dilator muscle and is inserted into the dorsal surface of the larynx. In older specimens, however, the greater part of the muscle becomes transformed into a fatty substance of a dark brown colour, similar to that which occurs in abundance around the pointed cartilage at the front of the hyobranchial skeleton and on the underside of the alæ. Such part of the muscle as remains unchanged is attached to the postero-lateral corners of the laryngeal skeleton, in the position already recorded for it by Mayer (**25.** p. 536) and Henle (**19.** p. 26 and Taf. 2. figs. 14 and 23, *7′*). At no age does the muscle develop a tendinous extremity as it does in *Xenopus*.

Male.

For details of the laryngeal muscular system of the male *Pipa*, I have been obliged to rely entirely on the account given by Grönberg, for both Mayer's and Henle's descriptions of these muscles refer to the female, and although I have had access to three specimens of the male, they were all unsuitable for a careful examination of their muscular anatomy. Grönberg describes (**18.** p. 638) four intrinsic muscles of the larynx. For the muscle around the glottis he accepts Henle's name Compressor: it appears to correspond exactly with that muscle which in the female I have called the compressor, so that it is unnecessary to discuss it further. The other three, however, open up debatable points. They arise from the sides, roof and floor * of the larynx, and extend nearly its full length; and their bellies are so united that Grönberg confesses his inability to decide whether they are three originally distinct muscles, or whether they are divisions of the same muscle, its tendon having split into three. He elects to adopt the former view. The tendon of the most dorsally-lying muscle (**18.** Taf. 38. figs. 19 and 20, *S 1*) is attached to the arytenoid cartilage guarding the glottis, and this muscle he identifies as the "dilatator laryngis" of *Rana*. The tendon of the ventrally-disposed muscle (**18.** figs. 18 and 20, *S 3*) runs to the external promontory of the ossified part of the arytenoid, and the contraction of the muscle serves to approximate the bony arytenoid rods lying in the laryngeal cavity. Since Grönberg regards these ossified parts as external arytenoids not represented in other Anura, he is

* Henle (**19.** p. 26) states that in the male *Pipa* the whole of the ventral surface of the larynx is covered by muscle, an observation which is not borne out by Grönberg's figure (**18.** Taf. 38. fig. 18).

forced to conclude that the muscle also is unique. He does not suggest any name for it. The third muscle overlaps the other two on the external or lateral surface of the larynx, and its tendon (**18.** fig. 20, *S 2*) unites antero-ventrally to the glottis with its fellow of the opposite side. From these relations he considers it to represent the "hoher, lateralwärts liegender Constrictor des Larynx" of Ecker (**11.** p. 31, fig. 14, *c.a.l.*) (called in the English edition the "Constrictor aditus laryngis," **12.** p. 314, fig. 205, *c.a.l.*).

On comparing Grönberg's figures of the male with mine of the female, it will, I think, be evident at a glance that the dorsal muscle, the tendon of which he marks *S 1*, is that which I have called the dilator anterior (Pl. **10.** fig. 5, *d.a.*). The tendon in both cases is inserted into the edge of the arytenoid cartilage at the side of the glottis, and it is quite possible to conceive that the muscle has assumed a more antero-posterior direction in the male, in consequence of the glottis opening directly forwards, towards the aperture of the mouth, instead of upwards as in the female. The other two, *S 2* and *S 3*, I take to correspond with my dilator laryngis. Although in both sexes of *Xenopus* the insertion of the dilator lies entirely behind that of the dilator anterior (Pl. **10.** figs. 2 and 4), yet in the female of *Pipa* the attachment of the tendon of the dilator to the promontory of the arytenoid is situated farther forward than the insertion of the anterior dilator into the side-wall of the glottis (Pl. **10.** fig. 5). Assuming, as I think we are justified in doing, that the promontory of the female arytenoid (Pl. **9.** fig. 2, *d*) is equivalent to the similar promontory of the male which Grönberg marks *a* in his figures 10, 11, 13, and 14, it is but logical to regard his ventral muscle, *S 3*, and my dilator laryngis as identical. This leaves only his muscle *S 2* unaccounted for.

I have not been able to recognize in the female *Pipa* any third dilator, nor any union of tendons anterior to the glottis; but in both sexes of *Xenopus* there is an imperfectly differentiated slip of the dilator (Pl. **10.** figs. 2 and 4, *d'*), the tendon of which is elongated and inserted into the massive part of the arytenoid. It is true that in *Xenopus* the insertion of the slip is far behind that of the dilator anterior and the glottis, but an examination of fig. 5, Pl. **10**, will show that a similar slip differentiated from the more dorsal part of the dilator, on the rotation of the glottis forwards, would come to occupy the position of Grönberg's *S 2*.

It now only requires an extension of the tendons to meet below the glottis to complete the resemblance. The changes in the relative positions of the bellies of the muscles would follow as a consequence of the rotation of the glottis. The dilator anterior would straighten out and occupy a dorsal position, leaving the greater dilator on the ventral surface of the larynx and its accessory slip laterally. As an alternative view, it may be suggested that the ventral muscle, *S 3*, which Grönberg says is absent in the frog, is the equivalent of that curious muscle which in *Discoglossus* and *Alytes* runs from the *ventral* surface of the posterior epiphysis of the thyrohyal to the ventro-anterior point of the arytenoid cartilage. Wilder figures the muscle in *Alytes* (42. Taf. 20. figs. 36 and 37) and regards it as the displaced constrictor laryngis, which otherwise must be admitted to be absent. Whether Wilder's interpretation is correct must remain for future investigation to decide: the two muscles do not unite in front of the glottis as do the constrictors of the frog.

These conclusions savour, no doubt, of conjecture, being based on the study of figures only, drawn by two different authors, each of whom has examined the muscular system of one sex only. In spite of the interesting union of the tendons *S* 2 antero-ventrally to the glottis, I am not disposed towards an unqualified acceptance of Grönberg's determination of the muscles as the constrictors of the common frog. An exhaustive study of the muscles, extrinsic as well as intrinsic, of the larynx of the male and female *Pipa* would most assuredly repay any investigator fortunate enough to have the necessary material at his command.

Development of the Hyobranchial and Laryngeal Skeleton.

The development of the hyobranchial and laryngeal skeleton of the Aglossa is practically unknown. Parker's treatise on the development of the skull of *Xenopus* and *Pipa* (33) is the only work to which we can turn for information; and this does not furnish much. On comparing the hyobranchial skeleton of the tadpoles of *Rana*, *Alytes*, *Pelobates*, and *Bufo*, one is struck by the uniformity of structure that exists in the different genera during the earlier stages of development; and the observations now to be recorded show that the skeleton of *Xenopus* and *Pipa* conforms to the general ground-plan. The various modifications

that render it so aberrant appear only during and after metamorphosis. This is of course the conclusion one would expect to arrive at; but hypotheses, conjectures, and arguments are of infinitesimal value compared with ocular demonstration of fact.

Concerning the methods adopted in this portion of the research, extensive preliminary trials were made on the tadpoles of the common frog and of *Alytes*, with a view to discovering the method which would demonstrate the facts in the most intelligible manner, and yet leave the skeleton in a condition in which it may be preserved for subsequent examination. The easiest methods of preparation are those which fail to satisfy the second condition. The steeping of the body in water at a temperature of about 80° C., a method largely used for the preparation of the skeleton of Elasmobranch fishes, was rejected at once on account of the shrinkage and distortion which it occasions. Putrefactive maceration, which may sometimes be employed with advantage in the preparation of cartilaginous skeletons, was found unsatisfactory on account of the tendency which the delicate skeleton showed to fall to pieces, and the possibility of loose cartilages becoming lost or overlooked—objections from which the hot-water method is not free. As I had previously found the method of staining with borax-carmine and clarifying with clove-oil of the greatest value when studying the carpus and tarsus of Anura, larval as well as adult (**23**), I applied the process to the branchial skeleton; but had to discard it on account of the resulting brittleness of the tissues. Clarifying by glycerine and caustic potash I also tried; but the preparations made in this way cannot be kept permanently in the clarifying fluid, since the potash brings about the ultimate disintegration of the cartilages. Parker's method, of staining with an ammoniacal solution of carmine and then steeping in glycerine, is open to less objection than the preceding methods; but it resembles them all in being inapplicable at the critical period when the cartilages are becoming absorbed,—the most important stage of all. All methods involving clarification and the use of transmitted light fail utterly here. I was therefore forced to fall back on the very simple expedient of dissecting the parts under a simple microscope by powerful reflected light: a tedious and delicate operation, it is true; but with fine instruments, combined with a knowledge, to be gained only by experience, of the relative toughness of muscle, perichondrium, and cartilage, the difficulties can be overcome.

A short trial was given of that method of investigation which is now finding such favour with embryologists, and which has been employed with such excellent results by Gaupp (14) in his investigations on the hyobranchial skeleton of *Rana fusca*. The head or other part is cut into microscope-sections of known thickness, and the organs to be studied are reconstructed therefrom in wax plates, the thickness of which is the same multiple of the original as the linear magnification. The wax sheets are then pressed together, and an enlarged model of the organs is thus obtained. Without in the least wishing to depreciate the results of Gaupp's investigations, for which I have the greatest admiration, I would point out that at the critical periods, when the cartilages are forming or are becoming absorbed, their outline is extremely difficult to make out in sections, and that in fashioning the wax plates it is very largely a matter of personal opinion to decide where the line shall be drawn between the cartilage and the surrounding tissues; and thus an error of a centimetre or more, according to the magnification, may very easily creep into the model. If the sections are cut thin, this difficulty of discrimination increases; while if the sections are thick, it is almost impossible to represent truthfully in the model narrow rod-like structures which make a small angle with the planes of section. The method is even more tedious than that of actual dissection by reflected light, and far less satisfactory and conclusive.

I had already completed this portion of the investigation by the time that Wilder's paper (42) reached me; and so I did not include a trial of the method he adopted in his recent work on the adult laryngeal skeleton of Amphibia, viz., that of mounting in turpentine and Canada balsam after slow staining with a weak alcoholic solution of methyl-blue, washing, and dehydrating. I have since made a few experiments in this direction, and can testify to the differentiating action which the dye has upon hyaline cartilage. The method, however, is useless for the demonstration of cartilage which is just forming or is undergoing absorption, and could not therefore be applied successfully to such purposes as the present.

Xenopus lævis.

Of the large number of tadpoles of *Xenopus* examined, it must suffice to choose only three stages for minute description and delineation, because in the earlier stages of development the

hyobranchial skeleton undergoes but little change, and that very slowly; and because the later stages, at which the metamorphosis is actually taking place, I have been unable, in spite of strenuous endeavours, to procure. I have already delayed the publication of this paper several months in the hope of being able to obtain the latter stages; but as there seems to be no prospect of achieving this in the near future, I submit such results as I have already obtained. For most of the specimens examined I am indebted to the generosity of Mr. G. A. Boulenger, F.R.S.

In making comparison of different tadpoles of the same species, I find that actual size is no criterion of the degree of development, since so much depends on the favourable or adverse conditions of life. The carefully recorded measurements of Parker's *Xenopus* larvæ were useless to me for correlating his tadpoles with mine. The only reliable data are afforded by the extent of development of the paired limbs. The oldest of the three chosen stages (Stage III.) is characterized by the presence of all four limbs, the fore as well as the hind being well developed, and by the possession of a large tail which shows no signs of absorption. The larvæ of the second stage have the hind limbs powerfully developed; but the fore limbs are only half as large as in Stage III. The first stage is a most comprehensive one, including tadpoles with hind limbs well developed and with the fore limbs recently extruded; tadpoles with hind legs not yet markedly flexed and with no trace of fore limbs; tadpoles with the hind legs just appearing on the surface of the body; and tadpoles with no traces of paired limbs at all. There is no appreciable difference beyond one of size in the hyobranchial skeleton of any of these tadpoles of Stage I.; but a trifling variation can be discerned in the relative size of the larynx.

In the figures of the developing hyobranchial skeleton (Plate **11**) the mandible is included, because it serves to give an idea of the size of the mouth at each stage—a most desirable item of information,—and because it demonstrates the relative hugeness of the hyoid arch, and shows that while the hyoid and mandibular arches are closely approximated in *Xenopus*, they are widely separated in the corresponding stages of *Pipa*. The ossifications in the mandible are not indicated in the figures. Parker shows (**33**. Pl. 56. fig. 6, and Pl. 58. fig. 4) a pair of "mento-meckelian" or "inferior labial" cartilages in the symphysial region of the mandible of the early larva of *Xenopus*. In this

position, however, I find not a pair of cartilages, but a single median piece which shows signs of division into two only in the third stage of development. This cartilage I take to be an integral part of the mandibular arch—in fact, the median inferior element or basimandibular. An examination of the first stage especially shows that, although the inferior portions of the mandibular and hyoid arches are so dissimilar in size, they are built essentially upon the same plan, and consist each of a pair of ceratal elements and a median basal piece (see Plate **11**. fig. 1). In this respect the mandibular arch of *Xenopus* exhibits the retention of a most primitive character.

The above interpretation of the symphysial cartilage opens up the question of the morphological value of mento-meckelians in general; and I am inclined to think that, in Anura at least, the symphysial cartilages or bones are not labials developed, as the upper labials undoubtedly are, in special relation with the suctorial lips, but the modified right and left divisions of a median basimandibular. The mouth of the young *Pipa* and *Xenopus* is not suctorial, but has the form of a wide slit from the very first; and this fact it is which gives the young of the Aglossa such a fish-like appearance. I have not been able to satisfy myself concerning the presence of mento-meckelian cartilages in *Pipa*. The mandible exhibits a symphysial segmentation as early as Stage II. (fig. 5); and at Stage VI. (fig. 9) the two rami are as distinct as in the adult. As already shown by Parker (**33**. pp. 638, 651, and 655), no symphysial elements are to be recognized in the adults of either *Xenopus* or *Pipa*.

Stage I. (Plate **11**. fig. 1.) *Tadpoles ranging from those in which the hind legs are just appearing, to those with the fore legs recently extruded.*

The branchial skeleton has attained its maximum larval development; but it as yet shows no signs of absorption. On comparing the hyobranchial skeleton of *Xenopus* at this stage with that of a more familiar anurous batrachian, e. g. *Rana* or *Alytes*, one cannot fail to notice how small are the three branchial clefts in proportion to the large expanse of the branchial cartilage. Instead of four elongated bars of cartilage on each side, connected distally by an epibranchial marginal bar, and confluent proximally with a cartilaginous hypobranchial plate, we have rather a pair of greatly inflated cartilages of considerable size,

each approximately resembling in shape the half of a longitudinally divided egg-shell. The cartilage is thin and fairly uniform throughout, and is perforated ventrally by the three branchial slits sloping obliquely outwards, backwards, and slightly upwards. The two cartilages are closely applied one to another in the median plane for about one-half of their length. Their applied faces are nearly flat, and are readily separable, no fusion having yet taken place. The two cartilaginous basket-works look upwards and slightly inwards, and the inner and anterior edges are involute. Of the three branchial clefts the first is situated about halfway from the anterior end, so that in front of it there is quite a large extent of unbroken cartilage. This latter represents the first branchial arch of the tadpole of the frog. The length of the most anterior cleft is about one-half of the transverse diameter of the basket. The second and third clefts are nearly parallel with the first: they are successively shorter, and lie rather closer to the median line. The two bars of cartilage separating the three clefts are the second and third branchial arches, while the cartilage bounding the last cleft posteriorly represents the fourth branchial arch of the frog-tadpole. Seeing that in fishes the cleft is situated in front of the arch of the same denomination (*i. e.* that the first branchial cleft is bounded behind by the first branchial arch, and so on), the three clefts here present represent the second, third, and fourth branchial clefts respectively. It may seem unnecessary to insist on this point; but when three clefts occur, as here, in a continuous cartilage, there is a temptation to speak of them loosely as the first, second, and third, and then arises a danger of losing sight of their morphological enumeration.

The inner or pharyngeal surface of the branchial cartilage is not smooth, but is covered with a multitude of minute, blunt, arborescent growths. These are not shown in the figures. There are also sharply defined ridges running along the upper surface of the second and third branchial arches, and continued over the undivided cartilage both outwards, backwards, and upwards, to the external edge, and inwards, forwards, and upwards, to the internal overhanging border. These latter processes are evidently equivalent to those outgrowths in the branchial apparatus of the *Rana* tadpole which Gaupp calls spicula ii. and iii. (**14**. Taf. xvii. fig. 1), and to which Parker (**34**) attaches undue importance by calling them the true branchial arches. The flap-like outgrowth

of the antero-external edge (Plate **11**. fig. 1, *k*) is very constant in its occurrence; and this also is not unrepresented in the genus *Rana*.

The hyoid arch consists of three elements—two large massive lateral cartilages or ceratohyals (fig. 1, *ch.*), which later will form the anterior cornua of the hyoid apparatus, and a small median cartilage or basihyal (*bh.*). There are thus in the hyobranchial skeleton at this period five distinct and separable cartilages, as has been held to be the case in the tadpole of the common frog from the time of Cuvier (**8**) onwards. Gaupp states (**14**. p. 433) that in *Rana fusca* tadpoles the whole cartilage is continuous, without fibrous tissue intervening. I have not been able to procure tadpoles of this species; but I have made a careful examination of tadpoles of suitable age of *Rana esculenta* and *R. temporaria*, and in both of these the five cartilages are very sharply defined. I am inclined to think that the imperfections of the method adopted by Gaupp are largely responsible for his departure from the generally accepted view. As mentioned above, it is very difficult to discriminate between embryonic cartilage and fibrous tissue by their histological characters.

The ceratohyal or lateral hyoid bar is a stout massive cartilage closely wedged in between the branchial cartilage behind and the meckelian cartilage in front. The posterior edge is hollowed out superiorly so as to allow the anterior pointed extremity of the branchial basket to overlap it. The anterior edge of the ceratohyal is thin, and runs parallel with the attenuated mandible, almost in contact with it. The distance between the outer extremities of the hyoid arch is considerably less than the maximum diameter across the branchial skeleton. The two ceratohyals touch one another in front; but the posteriorly directed processes of their median ends are separated by the basihyal, and are wedged in between the divaricated ends of the branchial skeleton. The basihyal is cuneiform and pointed anteriorly. Its posterior surface is applied to the branchial cartilage immediately in front of the thyroid bodies *. I regard this median cartilage as the basihyal because of its intimate relation to the ceratohyals; but I am quite prepared to agree with Parker (**34**) that when, as in *Alytes*, six elements instead of five are present in the larval hyobranchial skeleton, the extra

* I am at a loss to understand why Parker (**33**. Pl. 58. fig. 3, *tr.g.*) figures the "thyroid glands" close up under the auditory capsule.

small cartilage between the ceratohyals is undoubtedly the basihyal, and that the larger, and more posterior, unpaired cartilage, which is of more constant occurrence, has rather the value of a basibranchial. Schulze (**38**) still holds to the original view of Dugès (**10**), that this latter is the basihyal (basihyoid).

The larynx at this stage is quite diminutive in size, and lies above the level of the internal reflected margins of the branchial cartilages. The width of the larynx is hardly more than that of one of the bronchi, and the length of the glottis is about half the width of the larynx. The bronchus is not sharply marked off from the lung, but appears rather as a tubular non-sacculated continuation of it. The bronchus and lung are about equal in length. As might be expected at this early stage, the lungs are very small, and the total length of bronchus and lung together is not more than the maximum transverse diameter of the branchial skeleton. Arising from the dorsal surface of the anterior end of each bronchus is a curious thin-walled sac (Plate **11**. fig. 1, *p*) which runs up laterally to the œsophagus, and is lodged beneath the ribs (see p. 120) of the anterior vertebræ. The significance of these sacs it is difficult to estimate: they are probably to be regarded as accessory lobes of the lung, since their walls so closely resemble the lung-tissue. They are present in all the larvæ of *Xenopus* that I have examined, but are altogether absent in the adult. I have found nothing to correspond with them in either the young or adult of *Pipa*.

Stage II. (Plate **11**, fig. 2.) *Tadpoles with fore limbs moderately well developed, pigmented, but not markedly angulate.*

By comparison with Stage I., the most important difference to be noted in Stage II. is the reduction in size of the branchial skeleton. The hyoid arch and mandible show no great change. The curvature of the outline in the dorsal view of the branchial skeleton is no longer seen, but each half is roughly five-sided. The inflation is less conspicuous, and the basket is considerably shallower. The overhanging fold at the anterior end is missing, although the ledge projecting outwards from the applied mesial surfaces still remains. The branchial clefts have not altered; and they serve to show that the absorption has been greatest anteriorly. The first branchial arch (Pl. **11**. fig. 2, *cb*. 1), which before fitted so closely into the concavity at the back of the ceratohyal, now barely overlaps the ventral ledge of that cartilage

The ceratohyal has not shared in this modification, and so a vacuity now exists between its outer end and the branchial skeleton. The anterior portion of the basihyal has been absorbed, and a cleft is beginning to appear between the median extremities of the ceratohyals. The distance between the outer ends of the ceratohyals is now slightly less than the maximum transverse diameter of the branchial skeleton. The larynx, bronchi, accessory pulmonary lobes, and the lungs are all larger than before, but are not otherwise noteworthy.

Stage III. (Plate **11**. fig. 3.) *Tadpoles with well-developed fore limbs, sharply bent. Absorption of the tail not yet commenced.*

Considerable changes have taken place in the hyobranchial skeleton since Stage II., far more than would be suspected from a superficial examination of the tadpoles. The five cartilages to be seen in Stages I. and II are no longer distinguishable. The basihyal has either been absorbed, or has fused up with the neighbouring cartilages in such a way as to leave a deep cleft, enlarging posteriorly between the median ends of the ceratohyals. The posterior end of this cleft marks the position of the future hyoglossal foramen; and it only requires a further enlargement of the cleft, accompanied by a secondary union of the ceratohyal cartilages in front, to bring about the adult relations. It is a matter of the keenest regret that I am unable, from lack of material, to add a circumstantial account of these later changes.

The mandible and ceratohyal have changed but little; and the concavity at the back of the latter, vacated by the first branchial arch, still remains. The branchial skeleton, on the other hand, has been considerably reduced. The first branchial arch is now no thicker than the second, and a wide space intervenes between it and the ceratohyal. All trace of inflation has disappeared, and the flattened branchial apparatus bears a much closer resemblance to that of the common frog than it did before. The three branchial clefts have not altered except in size, and, judging by analogy with tadpoles of other species of Anura, they will not do so. The arches will be absorbed, and the clefts will disappear in consequence; but the latter will play only a passive part in the change. The distance across the branchial skeleton is now considerably less than the extreme width of the hyoid arch. That the absorption of the branchial skeleton has been a marginal one is seen by the fact that in the first stage the external edge of the

branchial basket-work fits underneath the auditory capsule so closely that considerable care is required to separate the two; but in this third stage the whole of the branchial skeleton lies in the floor of the pharynx.

The most interesting feature of this stage is the formation of the thyrohyals, which may be seen arising from the hind edge of the median basal plate of cartilage, as a paired outgrowth perfectly independent of the four branchial arches (Pl. **11**. fig. 3, *t*). This is universally accepted as the mode of origin of the thyrohyals in the tongued Anura. It was clearly set forth in the works of Cuvier (8), St.-Ange (**36**), and Dugès (**10**), was confirmed by Parker (**32**) in his exhaustive treatise on the development of the skull of the common frog, and has recently been corroborated by Schulze (**38**) and Gaupp (**14**). These thyrohyals as yet show no trace of ossification, and are quite free from the laryngeal skeleton. Here, then, is conclusive evidence of the secondary nature of that connexion between the hyobranchial and the laryngeal skeleton, which distinguishes the Aglossa from all other Amphibia. The fourth branchial arch has shrunk considerably since Stage II., especially towards its median end, so that not only is it now no thicker than the third arch; but it no longer underlies the larynx. In fact, although the larynx has not shifted in position relatively to the branchial clefts, there has appeared a space between the fourth branchial arch and the larynx. Into this space the thyrohyals grow.

Owing to paucity of material I have been unable to determine the mode of origin of the great alæ of the adult hyobranchial skeleton; but it is highly probable that, as in *Pipa*, these are the result of secondary outgrowths from the undivided hypobranchial part of the branchial skeleton (Pl. **11**. fig. 3, *hb*), and not, as might be suggested by a comparison of fig. 3, Pl. **11**. and fig. 1, Pl. **8**, of the persistence of such part of the branchial skeleton as still remains, under a condition of closure of the clefts. The ceratohyals, still massive, are fated to undergo a certain amount of absorption. The absorption, however, is not excessive, and the lamellar expansions of cartilage on the internal and external edges of the anterior cornua of the adult clearly owe their presence to the fact that the absorption of cartilage is less complete than in most Anura. The laryngeal skeleton has altered but little since Stage II. The arytenoid cartilages (Pl. **11**. fig. 10, *ar.*) are very large in proportion. They

resemble in shape the arytenoids of most Anura (cf. *Bombinator*, fig. 13), and differ in a marked degree from the arytenoids of the adult. They are closely applied to one another in the median line, as in the typical Anuran larynx, and not as in the adult *Xenopus*. The cricoid is an annular cartilage, more extensive on the ventral than the dorsal surface, and quite free from the thyrohyals. The ventral portion terminates anteriorly in a blunt point a short distance behind the anterior ends of the arytenoids, and is produced behind into a pair of narrow bands (fig. 10, *br.*) which support the ventro-internal walls of the bronchial tubes. This early appearance of the bronchial cartilages is well worthy of note. The roof of the larynx is expanded in front, and the dorso-lateral corners are produced into a pair of blunt processes which are doubtless to be identified with the blinker-shaped processes of the adult (Pl. **8**. fig. 3, *bl.*). The posterior edge of the roof is concave. The sides of the cricoid do not extend forward, so that the whole of the arytenoid can be seen in a side view.

Parker neither discusses nor figures the branchial skeleton of his youngest *Xenopus* larva—first stage, with no traces of paired limbs, total length $1\frac{1}{3}$ inch—but the figure he gives (**33**. Pl. 56. fig. 6) of the hyoid arch and mandible of this stage corresponds almost exactly with that of my Stage I. The broadened posterior extremity of the basihyal he regards as the first basibranchial, but beyond that we do not differ. Parker's second stage—tadpole, $1\frac{2}{3}$ inch long—of the limbs of which we have no means of judging, would also appear to correspond with my first stage; for in his side view of the hyobranchial skeleton (which, curiously enough, he draws upside down), the branchial cartilage is still considerably inflated and fits up closely behind the ceratohyal. He is silent concerning the hyobranchial skeleton of his third stage,—tadpoles at their largest size—; but in his fourth stage—young, with large legs and diminishing tail—which, judging from the second qualification, should be older than my Stage III., he figures (**33**. Pl. 58. fig. 4) the two ceratohyals as still distinct, and the basihyal as still recognizable. The cartilage, which in this figure he indicates by outline only and marks *br.* 1, is, I am convinced, the whole of the hypobranchial plate, shown in my fig. 3 at *hb.*

Pipa americana.

Here, as in *Xenopus*, the mode of development of the hyobranchial skeleton is practically unknown. Parker has contributed a certain amount of information*, but beyond this the subject has not been touched. Grönberg (**18.** p. 635) speaks of having discovered in the larva of *Pipa* that, as in the adult female, the isthmus between the anterior and the posterior parts of the basal plate is a continuous cartilage, but he gives no further information, nor any figures of larval structures. The specimens available for this part of the investigation were sufficiently plentiful to render it possible to obtain much more complete and satisfactory results than was the case with *Xenopus*. For many of the specimens I am indebted to the kindness of Prof. G. B. Howes; the remainder were obtained by purchase from V. Frič of Prague.

It will be found convenient to choose six stages of development for description here. There is more uniformity in the size of embryos of the same age than in *Xenopus*, since the young of

Embryos of Pipa.

Measurements in millimetres.

	From snout to root of tail.	Length of tail.	Length of extended hind limb.	Length of extended fore limb.
Stage I.	10	12	4	0
Stage II.............	12	11	6	3
Stage III.	11·5 13 12	6·5 8·5 10	7·5 7 7	5 5 5
Stage IV.	11 11·5 9 12	9 10 10 6	7·5 7 8 7·5	4·5 4·5 4·5 4·5
Stage V.	11 11	9 9·5	9 10	5 5
Stage VI.	14 13·5 15 13 14	0 0 0 3 0	10 11 11 10 10·5	5·5 5·5 8 6 5·5

* For a criticism of which, see p. 110.

Pipa are less dependent on external conditions, being provided at the outset with a large quantity of food-yolk, and being lodged during their development in the integumentary pits on the back of the mother. But it happens unfortunately that very little idea of the extent of development of the hyobranchial skeleton can be obtained from an examination of the external features, and it is consequently necessary in most cases to dissect out this portion of its body before deciding what stage any particular embryo has reached. The table on p. 102, compiled from the *Pipa* embryos examined, will show how useless actual measurements are for discriminating the various stages. Stage I. is distinguished by the fact that the fore limbs are not yet extruded, and Stage VI. is marked by the complete absorption of the tail; but there is no safe guide for distinguishing the intermediate stages.

Stage I. (Pl. **11**. fig. 4.) *Embryo with abdomen much distended by unabsorbed yolk. Fore limbs not yet extruded. Length of body* 10 *mm., tail* 12 *mm.*

I have called this Stage I. because it is the youngest that I have been able to examine; it is, however, highly probable that the hyobranchial skeleton of younger embryos would show many features of interest. Owing to the fact that the larvæ of *Xenopus* are freely-swimming tadpoles, while the young of *Pipa* only quit the integumentary pits on the back of the mother after their metamorphosis is complete, it is no easy matter to correlate the stages of development in the two genera; but, judging from the extent of development of the hyobranchial skeleton alone, this first stage of *Pipa* would seem to be equivalent to a stage intermediate between those numbered II. and III. in *Xenopus*. The branchial arches are rods of cartilage and not sheets, as in the early stages of *Xenopus*, and the lines of demarcation of the five elements of the larval hyobranchial skeleton are not to be distinguished. The hyobranchial skeleton is one continuous cartilage, considerably broader across the branchial than across the hyoid region. The branchial skeleton has the appearance of having already suffered considerable absorption. The larynx lies in the deep indentation in the middle of the posterior border, and does not overlie the branchial cartilage. The three branchial clefts are approximately equal in length, but in width the posterior has the advantage. The first branchial arch is separated

from the hyoid by a distance equal to its own width; and the breadth of the cartilage connecting the hyoid and branchial divisions of the hyobranchial skeleton is nearly equal to the antero-posterior diameter of the median basal plate, from which latter the four great lobes, two hyoid and two branchial, radiate.

The hyoid cornua are large, and each in shape resembles an axe-head. The antero-external convex edge is thin and shows signs of absorption. It is important to note that, although the external or lateral extremities of the mandible and ceratohyal are nearly in contact, a considerable space is enclosed between their more median parts, and these relations are maintained as long as the ceratohyal is recognizable. In *Xenopus*, it will be remembered, the median ends of the ceratohyals lie close up behind the mandible. Although the hyobranchial skeleton of the early *Pipa* embryo exhibits the aforementioned peculiarities, it is nevertheless far less aberrant than that of the *Xenopus* larva.

Parker states (**33.** p. 649) that there are neither external nor internal gills in the embryos of *Pipa*, but it is evident that he had never seen Wyman's paper describing (**44.** p. 371) the existence of three pairs of external gills, internal gills, and a pair of branchial clefts. It would be difficult to believe that a hyobranchial skeleton, conforming so closely to the normal anuran type as does that of the present stage, should not be associated with branchiæ of some sort.

STAGE II. (Pl. **11.** fig. 5.) *Embryo with abdomen not distended by yolk, although on dissection much is found still unabsorbed. Hind limbs flexed,* 6 *mm. in length when straightened out. Fore limbs* 3 *mm. Length of body* 12 *mm., tail* 11 *mm.*

This stage does not differ to any great extent from the first, and is not so strictly intermediate between Stages I. and III. as could be wished; but here again the deficiency is to be accounted for by the difficulty of obtaining embryos of any particular age. The chief difference between this and the preceding stage is to be noted in the hyoid arch. Considerable absorption has taken place—a significant foreshadowing of the later complete disappearance of this arch. The erosion is greatest anteriorly, so that the antero-external edge, before convex, is now concave, while the anterior indentation between the two cornua has broadened out. Since no absorption yet

takes place at the free extremities of the cornua, there is no diminution in the total width of the hyoid skeleton. The most important change which has taken place in the branchial skeleton is the severing of the commissural or epibranchial cartilage between the lateral extremities of the first and second branchial arches. An indication of this is to be seen in Parker's figure (**33**. Pl. 63. fig. 4) of a stage much earlier than this. It is interesting as being the first step in the total disintegration of the branchial arches which so soon supervenes. The larynx has advanced in position so that it is now in contact with the branchial skeleton.

Stage III. (Pl. **11**. fig. 6.)

It is impossible to give a diagnosis of embryos of this and the two following stages, as a glance at the table of measurements will show. The changes in the hyobranchial skeleton at this period appear to be unaccompanied by any marked alteration in the external appearance of the embryo.

The general aspect of the hyobranchial skeleton is now entirely changed, and the absorption of cartilage is proceeding rapidly. The hyoid cornua are reduced to rods of cartilage, while the branchial arches are breaking up, chiefly at their peripheral ends. Before proceeding to a detailed description of the skeleton at this stage, it may be well to point out that in *Xenopus* the hyoid arch remains practically unchanged during the time that the branchial arches are undergoing their gradual reduction, but that in the early stages of *Pipa* it becomes rapidly diminished and the branchial skeleton follows but slowly. At Stages III. and IV. of *Pipa* the rapid absorption of the branchial arches begins, and then it is a race, as it were, between the hyoid and branchial arches for first disappearance. The rate of absorption at this period is excessive, so much so that embryos the hyobranchial skeleton of which has reached Stages III. and IV., and even V., are externally indistinguishable: in other words, that the rate of change in the hyobranchial apparatus exceeds by a good deal that of the general metamorphic changes of the body.

In this Stage III. the diameter across the branchial skeleton is not greater than that across the hyoid arch. This may be partly due to an elongation of the hyoid cornua; but the more important factor in this change of proportion is undoubtedly a *shrinkage* of the branchial arches. This is indicated to some

extent by the shortening of the branchial clefts before they become broken open peripherally; but it is more conclusively shown by the fact that, while in Stages I. and II. the aortic vessels made up of the four efferent branchial arteries run alongside the commissural or epibranchial cartilages that connect the outer ends of the branchial arches, there exists in Stage III. a considerable interval between the paired aorta and such parts of the commissural cartilages as yet remain. This is not to be explained by a widening or separation of the aortæ, for the actual length of the branchial vessels has not increased. The commissure between the first two arches was already ruptured in Stage II.: it has now completely disappeared. The second commissural cartilage has severed its connexion with the second branchial arch, but remains attached to the third. The third commissure is still intact. The first branchial arch is undergoing reduction at its proximal as well as at its distal extremity. The cartilage at the junction of the first ceratobranchial and the hypobranchial plate (Pl. **11**. fig. 6, †) is very thin, and showed in two of the specimens examined a distinct indentation in the edge,—a foreshadowing of the dismemberment of the arch which is completed in Stage IV. A considerable reduction is to be noticed in thickness of the second branchial arch. The fourth arch, on the contrary, is thicker than before, especially towards its proximal extremity, where it is in continuity with the hypobranchial plate. The latter plate has become perforated by a paired foramen (t') lying immediately over the thyroid bodies. The cartilage situated to the outer side of the foramina shows unmistakable signs of absorption, but the front and hind portions of the hypobranchial plate are increasing in thickness.

The thickening at the posterior edge of the plate is highly important, because, as will be seen by comparison with the later stages, it indicates the formation of the thyrohyals. The thyrohyals in *Pipa* do not grow out as distinct processes as they do in the tongued Anura, and even in *Xenopus*, but are formed by an addition of cartilage to the hind edge of the hypobranchial plate. The added cartilage also extends outwards behind the proximal end of the fourth branchial arch, and this it is that causes the apparent increase in thickness of the last arch. There is no augmentation of the cartilage of the arch, but an addition to its posterior edge. This is indeed a most aberrant mode of formation of the thyrohyals, unparalleled in the Anura; but the

development conforms to the general rule in so far that the thyrohyals arise from the hinder part of the hypobranchial plate, and at the proximal end of the fourth branchial arch.

The thickening of the anterior portion of the hypobranchial plate is the developing ala of the hyobranchial skeleton of the adult. It is situated, strictly speaking, anteriorly to the level of the first branchial arch, from which it is already beginning to separate by the formation of the notch shown at † in fig. 6. The bar of cartilage lying in the median line between the two foramina will become the isthmus (Pl. **9**. fig. 1, *i*) which connects the anterior and the posterior or laryngeal parts of the basal plate of the adult. The hyoid cornua or ceratohyals are much thinner than in Stage II. and are slightly longer. They are of approximately uniform thickness all along, except at their median extremities, where they are reduced. They are delicately curved, the anterior margin being convex and the posterior concave. The space between the hyoid and first branchial arches has increased in size, and the indentation between the two hyoidean cornua is no longer V-shaped but semicircular, with a slight tendency to squareness. The larynx, which has increased but little in size, now overlaps the developing thyrohyals *.

Stage IV. (Pl. **11**. fig. 7.)

The difficulty experienced in dissecting out the branchial arches in the last stage, owing to the looseness and softness of the disintegrating cartilage, here reaches a maximum; and it is only with the very greatest care that the arches can be recognized at all. All four have severed their connexion with the hypobranchial cartilage, and the epibranchial or commissural cartilages at their distal ends have completely disappeared. The part of the hypobranchial cartilage postero-external to the thyroid foramen and between the developing ala and thyrohyal is not yet entirely absorbed, but the tissue in this position is of a very loose character. The most instructive lesson that this stage teaches is that the ala of the adult skeleton is a purely hypobranchial derivative and that it is morphologically anterior to the first branchial arch. Parker's interpretation, therefore, of the ala as the confluent first and second branchial arches of the larval skeleton is no longer tenable.

* In order to avoid confusion, it has been omitted in figs. 6, 7, and 8; its position in fig. 9 is indicated by the dotted line.

In the hyoid arch the absorption has been greatest towards the median extremity, so that the cornua taper inwards to a point which is still connected by a very ill-defined tissue with the axial structures. A new cartilage, as yet but faintly outlined, is appearing between the inner ends of the hyoid cornua, and tends to convert the notch or indentation at the front of the hyobranchial apparatus into a foramen. The larynx now completely overlies the developing thyrohyals, and its most anterior point is situated exactly over the middle of the median bar or isthmus between the thyroid foramina.

Stage V. (Pl. 11. fig. 8.)

The ceratobranchials have completely disappeared at this stage, and the thyroid foramina have been converted into deep clefts between the alæ in front and the thyrohyals behind. Both alæ and thyrohyals are now sharply outlined, and the whole apparatus has begun to assume the peculiar aspect of the hyobranchial skeleton of the adult. The alæ are racket-shaped. The hyoglossal notch has been converted into a complete foramen (fig. 8, *h*) by a further development of the cartilage which in Stage IV. was beginning to make its appearance between the median ends of the hyoid cornua. The new cartilage has assumed a definite outline and tapers anteriorly to a blunt point. The ceratohyals themselves are only to be recognized as vestigial cartilages, blunt externally and pointed at their inner ends, situated behind and internal to the articular end of Meckel's cartilage. It is here worthy of remark that the absorption of the hyoid cornua has proceeded in a most regular manner from the median end outwards, the last remnant to disappear being the external extremity. There is nothing to be recorded with regard to the laryngeal skeleton except that it has been gradually increasing in size, and that its diameter is now as great as the distance between the centres of the alary cartilages.

Stage VI. (Pl. 11. fig. 9.) *Embryos with no tail, or with the merest remnant of it. Length of body about* 14 *mm. Length of hind limb when extended* 10 *or* 11 *mm. Fore limb* 6 *mm.*

Although the embryos at this stage are still comfortably ensconced in the maternal integumentary pits, the hyobranchial skeleton does not differ materially from that of the fully-grown adult, the most important differences being that the thyrohyal is

unossified and still readily separable from the larynx proper. The thyrohyals have increased in length so that their extremities can be seen projecting beyond the sides of the larynx. Their extremities have also become dilated. The alæ have enlarged very considerably, and the maximum transverse diameter of the hyobranchial skeleton is now three times the width of the larynx. The backward growth of the alæ is even more remarkable than their increase in width. The line joining the extremities of the thyrohyals passed behind the alæ in Stage V., with a considerable distance to spare. In the present case it passes approximately through the centres of the now oval alary plates.

The hyoglossal foramen is nearly circular in shape and is much smaller than before. The cartilage bounding the foramen has been greatly reduced in thickness, and the anterior tapering process (Pl. **11**. fig. 9, *ch'*.) is now as sharply pointed as in the adult. The larynx is still remarkably different from that of the adult. This is a noteworthy fact, because Wilder (**42**. p. 306) states that in *Rana* tadpoles, the caudal stump of which has not yet disappeared, the larynx is practically in the adult condition. No peculiarities which might be attributed to sexual differences were to be seen in the larynx of any of the specimens examined. Since, however, the reproductive organs were not sufficiently advanced to enable me to determine the sex, it was not to be expected that any of the secondary sexual characters should be recognizable.

The arytenoid cartilages have the form which obtains in most adult Anura; they are pointed in front and are closely applied to one another by their thin dorsal borders. Their broad posterior ends fit closely into the ring of the cricoid cartilage, the ventral portion of which is produced forwards to furnish additional support (see figs. 11 and 12). The dorsal portion of the cricoid ring has the form of a band running transversely, and both anterior and posterior edges are nearly straight. The sides are more extensive than in *Xenopus* Stage III. (see fig. 10), and the floor, which is roughly triangular in shape, is deeply incised behind. A comparison between this embryonic larynx and the adult larynx of *Bombinator* (fig. 13) is very instructive. The bronchial processes (*br.*) of the latter are not represented, and the roof of the cricoid is not so expanded, but otherwise the resemblance is very close. The ventral position of the thyrohyals with regard to the larynx in *Pipa* is of course exceptional.

It has been brought about, not by the approximation of the thyrohyals towards the median line, but by the forward migration of the larynx over the hinder part of the hyobranchial skeleton. The membranous space in the floor of the larynx in the adult female (Pl. **9.** fig. 1) has evidently arisen by the absorption of cartilage, for it is not represented in any of the young stages. In this, as in the five preceding stages, the lungs exhibit the accessory lobe on the mesial surface, which is such a distinguishing feature of the lungs of the adult *Pipa*. The bronchi are still short,—a matter of some importance, since in *Xenopus* the bronchus is nearly as long as the lung itself even in the earliest stage.

Parker includes, in his first stage of *Pipa*, embryos from the dorsal pouches, of a total length of 9 lines, apportioned as follows :—head 2, body 3, tail 4. The external appearance of the embryo (**33.** Pl. 60. figs. 1 and 2) would show that this stage is earlier than my first stage, since the body is very small in proportion to the size of the yolk-sac. But, judging by the figure of the hyobranchial skeleton (**33.** Pl. 60. fig. 4), it should be later, for both hyoidean and branchial plates are represented as less expanded than in my Stage I. Parker figures the hyoid portion of the hyobranchial skeleton as distinct from the branchial, the right and left halves of each portion being united across the median line. These confusing characters render a more exact correlation of the stages impossible. Parker's second stage—ripe young, $6\frac{1}{2}$ to $7\frac{1}{2}$ lines in length, no tail—is older than my Stage VI., and the hyobranchial skeleton does not differ materially from that of the adult, except that the thyrohyal is unossified. Parker states (p. 655) that the ceratohyal has disappeared, and indicates by a dotted line the position which it should occupy; but, since he records no stage intermediate between that at which the hyoid is "at its maximum" (p. 652) and that at which it has entirely disappeared, he cannot be said to have unequivocally proved the absorption. He mistakes the floor of the larynx for an expansion of the hyobranchial cartilage and calls it the second basibranchial; and he fails to differentiate the thyrohyal from the laryngeal cartilage, although the two are readily separable at this age. The ala of the adult hyobranchial skeleton he regards as a derivative of the first and second branchial arches, the thyrohyal

of the third and fourth, and the hyoglossal foramen as a secondary fenestration in the basibranchial cartilage. In none of these respects do my observations accord with his.

General Conclusions, and Discussion of the Affinities of the Aglossa.

The most important outcome of the study of the development of the hyobranchial skeleton which forms the subject of the preceding section is the demonstration of the fact that the wings of the adult skeleton cannot be regarded as the derivatives of any particular branchial arches, any more than can the two lateral processes of the body of the hyoid, lying between the anterior cornu and the thyrohyal, in the frog, which, as Gaupp (**14**) has so admirably shown, are developing independently, while the branchial arches are becoming absorbed. There is, it is true, a great temptation to homologize processes and projections of adult skeletal parts with structures of larval significance, but it is only by resisting the temptation that a due regard for observed fact can be assured. Careful inspection of the evidence upon which Parker bases his deductions shows it to be of the most scanty description, and discloses the fact that the homology he establishes between the alæ and the first two branchial arches, and between the thyrohyals and the third and fourth, is conjecture rather than a legitimate conclusion based upon the information in his possession. Cope does not accept Parker's interpretation of these structures, but it is extremely difficult to discover what his own views really are, for while he copies (**7**. Pl. 76. fig. 1) Parker's figure of the hyobranchial skeleton of *Xenopus* (**33**. Pl. 58. fig. 5), and marks the wings *cb.* 1 and the thyrohyals *cb.* 2, yet on p. 252 he states that the Aglossa have the *third* ceratobranchials greatly elongated,—and this in spite of his generalization (p. 234) that the thyrohyal of Salientia is the *fourth* ceratobranchial. The relations of the geniohyoid muscle point in the direction of the alæ being homologous with the lateral cartilages in front of the thyrohyal (processus postero-lateralis, Gaupp, **14**) which attain such an exceptional length in *Bombinator*, *Pelobates*, and *Pelodytes*. The anterior position, however, which the alæ occupy during development rather shakes one's faith in this determination.

The morphological significance of the thyrohyals in Anura

generally is a question which cannot be regarded as definitely settled. That they are only *physiologically* equivalent to the mammalian thyrohyals, which they so closely resemble, is tolerably certain. The thyrohyals are derived from the branchial skeleton in both, but from parts which are not homologous. The view propounded more than seventy years ago by Meckel (**27**. p. 240) and Cuvier (**8**. p. 397), that the thyrohyals of Anura represent the fifth ceratobranchials of Elasmobranch fishes and the lower pharyngeal bones of Teleosteans, is well worthy of mature consideration; and it may be a not unimportant fact that the fifth ceratobranchials are so much more strongly developed than the preceding four in most Rays and Teleosteans. When, later, the study of development disclosed the exceptional mode of origin of the Amphibian thyrohyals, authors became silent concerning their morphological value, and simply described them as outgrowths of the hypobranchial plate of the tadpole, behind the fourth branchial arch. More recently Parker (**35**. p. 173, and **34**), who was never at a loss for a working hypothesis, regarded them as the fourth ceratobranchials, and in this he has been followed by Walter (**40**) and others.

The fact of the thyrohyals arising so late and as outgrowths from the hypobranchial plate, and not, like the branchial arches, by differentiation of the cartilage, does not, however, appear to me to militate seriously against our regarding them as the fifth ceratobranchials. Their late development is certainly connected in some degree with their relation to the larynx, which, like the rest of the pulmonary respiratory system, does not attain any considerable development until branchial respiration is waning. Given five branchial arches, four of which are connected with branchial respiration and the fifth with pulmonary respiration, and considering that respiration is at first branchial and later pulmonary, it is in strict accord with such laws as we have been able to formulate concerning the development of structures not required for use simultaneously, that the fifth arch will not develop until it is wanted; and then, as is the case with most organs the development of which is delayed, it will be formed rapidly, and most probably in an exceptional manner. Similar instances of accelerated and abbreviated development of organs, the appearance of which has been delayed, may be seen in the formation of the mesonephros of the frog from a blastema instead of by peritoneal tubules, in consequence of the pro-

nephros subserving all the requirements of the tadpole until a late larval stage; and the direct development of the first three pairs of appendages in those Crustacea in which the Nauplius stage is suppressed,—the metamorphosis of the larval appendages is omitted, and when the appendages appear they assume directly the form of the antennule, antenna, and mandible of the adult. On this hypothesis the difference in the mode of origin of the thyrohyals in *Xenopus* and *Pipa* is probably not morphologically important.

In 1881 Parker (**34**) propounded the view that the four pairs of irregular cartilages (Spicula, Gaupp, **14**) at the junction of the branchial arches with the hypobranchial plate in the tadpole were the true ceratobranchials of the fish, and that the arches themselves were but extrabranchials,—accessory structures peculiar to the tadpole of Anura and not represented in the larvæ of Urodela. Also, that the fourth pair of these processes became the thyrohyals. This view, although entertained in some degree by Cope * (**7**. p. 244) and Schulze (**38**. p. 12), cannot be substantiated by the facts of anatomy and development. Gaupp (**14**. p. 414) forcibly describes it as "ganz absurd," and other writers, such as Stöhr (**39**) and Naue (**31**), still adhere to the earlier interpretation. The relation of the vascular tissue to the supporting cartilage in a tadpole is certainly exceptional, but this is due to the enormous size of the pharyngeal cavity and the thinness of its lateral perforated walls. The main branchial blood-vessels lie external to the cartilage in both tadpole and fish, whereas if the spicula are the true arches and the branchialia something external to them, the vessels should run upwards from the spicula to the roof of the pharynx. As it is, even the paired aorta lies external to the branchialia of the tadpole.

Marshall (**24**. p. 164) describes a pair of diverticula in the floor of the pharynx, behind the last gill-clefts in *Rana* tadpoles, which disappear after the metamorphosis, and he takes them to represent in a modified form a fifth pair of branchial clefts. He does not explain their relations to the thyrohyals, but since he says the pits are situated at the sides of the glottis it is evident that they are in their immediate vicinity. The presence of anything that can be regarded as the fifth branchial cleft lends support to the hypothesis that the fifth branchial arch is also represented.

* Cope, however, contradicts himself by regarding the arches in Pl. 50. fig. 2 as ceratobranchials.

With regard to the arytenoid cartilages, authorities are all agreed that they are the most anterior segments of the tracheal skeleton: the point of dispute concerns the origin of the latter. Recent literature (Gegenbaur **15**, Göppert **16**, Wilder **41** and **42**) shows that there is a rapidly growing tendency to regard all tracheal, bronchial, and arytenoid cartilages in Amphibia as products of the segmentation of a pair of elongated cartilages—the fifth branchial arches—extending primarily along the right and left sides of the trachea. The determination turns chiefly upon the arrangement of these lateral cartilages in the lower Urodela; but it must not be forgotten that in these we are dealing with long-bodied animals in which the length of trachea is evidently correlated with that of the body: that is to say, that the organ under consideration is not in its most primitive condition. The subject is far too extensive to discuss in the limits of these pages, but, in the case of Anura, there appears to me to be far more to recommend the homology of the fifth branchial arch of the fish with the thyrohyal than with the arytenoid and cricoid cartilages.

I regard the laryngeal cartilage of the frog as the perfect equivalent of the cricoid cartilage of mammals, and I do not see the force of Wilder's argument (**42**. p. 285) for calling it the "annulus;" for, admitting that thyroid cartilages of whatever form are secondary * hyobranchial derivatives, and that the cricoid cartilage is formed by the modification of the first one or more tracheal rings, there is sufficient differentiation of laryngeal structures here for all practical purposes. If the word "cricoid" be employed in a strict sense, we should have to confine its application to mammals, and to invent new names for the chief laryngeal cartilage in other air-breathing vertebrates, according to the amount of tracheal cartilage involved.

With the thyroid cartilage the case is different, and the term must be employed more cautiously or hopeless confusion will result. Grönberg, for instance, says with regard to the floor of the larynx of *Pipa* (**18**. p. 635):—"Wenn Dubois' Anschauung richtig ist, dass die Cartilago thyreoidea bei den Säugethieren aus dem 4. und 5. Visceralbogen nebst zugehöriger Copula hervorgegangen ist, so können wir hier zum ersten Mal im

* I use the word advisedly, in view of the prevailing custom, just cited, of regarding the whole of the respiratory cartilages as primary branchial derivatives.

Thierreich von einer Cartilago thyreoidea im Sinne des Säugethierschildknorpels sprechen." But, as already objected by Wilder (42. p. 291), if we apply the term "thyroid" to products of the fourth and fifth visceral arches (*i. e.* the second and third branchial arches), we must certainly not employ the same word for structures developed *behind the fourth branchial arch*, although perhaps the two may be physiologically identical. Mayer (25. p. 541) had previously applied the term "os thyreoideum" to the anterior part of the floor of the larynx of *Pipa* (not the whole of it, as Grönberg appears to intimate), but he probably did not intend the comparison to be taken too strictly. It is sufficiently misleading to employ the same word thyrohyal in Anura and Mammalia for structures only functionally similar; but custom has so familiarized us with the enormity that we have come to associate different morphological ideas with the word according to the animals to which it is applied. Still, this fact does not warrant the introduction into an already too involved literature of fresh sources of confusion.

It were rash to institute, as many do, a system of classification based on the characters of a single organ, or even a few associated organs; but since the systematist has recourse to as many structural differences and resemblances as are within his knowledge when drawing up a scheme of classification, it may be well to ascertain what weight may be allowed to the various details set forth in the preceding pages when applied to the solution of the problem of natural affinity. Both *Xenopus* and *Pipa* have elongated bronchi, which are absent in all Phaneroglossa; but it is somewhat doubtful whether the bronchial cartilages supporting them have not originated independently in the two genera (see p. 71). The curious lobe of the lung arising from the dorsal surface of the anterior end of the bronchus in the larval *Xenopus* is not represented in *Pipa*; on the other hand, the outgrowth or lobe on the mesial surface of the lung of *Pipa* finds no counterpart in *Xenopus*. With regard to the larynx, a greater difference exists between this organ in the male and female of *Pipa* than in the females of *Pipa* and *Xenopus*. In the male of both genera the laryngeal complex is connected by ligament with the bulk of the hyobranchial skeleton; but, since these ligaments do not correspond morphologically, it is evident that we are dealing here with nothing more than an adaptation to subserve

some physiological purpose, probably to give the larynx greater freedom of motion.

Both *Xenopus* and *Pipa* have, it is true, no tongue, but is it not just possible that there is some physiological connexion between the absence of tongue, the union of the eustachian recesses into a median ostium pharyngeum, the excessive development of the hyobranchial wings, the formation of a hyoglossal foramen, the elongation of the bronchi, the absence of vocal cords, the enlargement of the larynx, and its support by the hinder part of the branchial skeleton? Admitting that the same conditions acting independently on the two genera may have resulted in the loss of the tongue or some other of the above specified peculiarities, it is quite comprehensible that the other modifications have followed as concomitant variations. The similarity of the hyobranchial and laryngeal skeleton, so far as I am aware, has not yet been employed as one of the characters pointing to a natural affinity between *Xenopus* and *Pipa*; but were the attention of the systematist directed to this feature, he would probably interpret it as corroborative detail, whereas if, as above suggested, it is physiologically related to the suppression of the tongue, he would be doubling or perhaps trebling the importance of the aglossal character, and would not be adducing new evidence. It may, in fact, be that the enlargement of the larynx as an accessory sexual organ is the primary cause of all this modification, including even the suppression of the tongue. In the Discoglossidæ and Pelobatidæ, where, as already pointed out, the larynx is much more enlarged than in most Anura, and where the tongue shows unmistakable signs of reduction, we have some such correlation as that suggested, and, what is more, a diminution of the antero-posterior diameter of the basal plate of the hyoid, coupled with a great development of the lateral outgrowths of the plate.

In *Bombinator* and *Pelobates* the mesial ends of the hyoidean cornua are connected by a dense layer of connective tissue situated below the hyoglossal muscle; and in *Pelodytes* the cornua are actually in contact in the median line, so that only a fusion of the two is required to make a perfect hyoglossal foramen. This fact is very significant, since it is only in these genera, outside the Aglossa, that any indication of a hyoglossal foramen is to be met with. The anterior cornu of *Xenopus* is broad and expansive, and thereby exhibits a retention of a

primitive condition. Similar expansions of the anterior cornua are to be seen in *Bombinator* and *Discoglossus*. The absence of the anterior cornua in *Pipa* indicates a high degree of specialization, which finds its nearest parallel in *Pelobates* * and *Pelodytes*. In the adults of these genera we have a retention of the condition seen in Stage V. in the development of *Pipa*. The greater part of the cornua are missing, but the more posterior parts have not shared in the absorption. These remnants are flat and broad in front, but are rod-like behind, where they rise up behind the auditory capsule and become attached to the skull.

The laryngeal muscular anatomy, more especially the exceptional relations of the hyoglossus and petrohyoideus of *Pipa* and *Xenopus*, would seem to indicate a close affinity between the two genera; but, on the other hand, it must not be lost sight of that these relations are correlated with skeletal resemblances, and care must be exercised not to weigh the same evidence twice over. The absence in *Pipa* of the geniohyoideus internus, the posterior position of the origin of the hyoglossus, and the insertion of the laryngeal division of the obliquus internus into the roof of the larynx instead of the extremity of the thyrohyal, are differences of no slight importance, and differences, moreover, which are not connected with skeletal dissimilarity. The relations of the hyoglossus to the floor of the mouth prove, I think, most conclusively that both *Pipa* and *Xenopus* are descended from tongued forms. Both Mivart (29. p. 283) and Cope (7. p. 247) have regarded the absence of tongue as secondary, and the union of the eustachian tubes in the middle line as evidence of a higher development. The breadth of the pterygoid bones is evidently related to this second feature.

With regard to the general muscular anatomy, Beddard (2. pp. 848 and 849) has shown that *Xenopus* differs from *Rana* and resembles *Pipa* in the "enormous extension backwards of the *Latissimus dorsi*, the absence of the *Pectoro-cutaneus*, the attachment of the muscles covering the abdomen to the fascia covering the thigh, the presence of a sheet of muscle below the *Mylohyoid* which joins the *Deltoid*, and the existence of a special muscle running from the ilium to the lung and œsophagus." On the other hand, *Xenopus* differs from both *Rana* and *Pipa* in the

* Parker (34. Pl. 25. fig. 9) shows the hyoid cornua of *Pelobates* as complete, but this is a mistake.

"large size and attachment of the *Sartorius*, the single-headed *Semitendinosus*, the great extent of the *Pectoral*, which completely covers the *Sternoradialis*, and the large size of the *Glutæus*." It would be of great interest to see whether any of these nine peculiarities occur in Discoglossidæ and Pelobatidæ. The extent of development and the almost identical form of the "diaphragm," and the extension of the abdominal muscles on to the thigh in both *Xenopus* and *Pipa*, Beddard points out (**2.** p. 849), may possibly have arisen independently, in relation with the assumption of a purely aquatic habit, but he inclines to the belief that they are marks of real affinity. It is strange how very many of the structural peculiarities which would appear to point to a natural relationship between *Xenopus* and *Pipa* are more or less explicable as physiological adaptations.

Besides the families Xenopodidæ and Pipidæ, Cope (**6.** p. 99 and **7.** p. 253) includes in the Aglossa a third family, the Palæobatrachidæ, represented by extinct forms only. The special interest of the third family in this connexion lies in the fact that Wolterstorff (who gives, **43.** pp. 3–12, a most useful list of references to papers dealing with *Palæobatrachus*), regards the question of affinity as turning largely upon the relations of the thyrohyals to the other skeletal parts:—"Ob eine Zunge vorhanden war, weiss man noch nicht. Dies, also die Trennung von den Aglossa, müsste durch Auffindung von Zungenbeinhörnen bewiesen werden" (**43.** Theil i. p. 45). Wolterstorff, although admitting many points of affinity with the Aglossa, appears rather inclined to accept Boulenger's view (**43.** Th. ii. p. 75 (155)), that *Palæobatrachus* is most nearly allied to the Pelobatidæ among living Anura, and to the genus *Batrachopsis* in particular. Did the genus possess an ossified laryngeal skeleton intimately associated with the thyrohyals, the evidence of affinity with the Aglossa would be incontestable, for there is nothing approaching such a condition in any other Anura. On the other hand, should the hyoid apparatus prove to be free, the affinity would in no wise be disproved. A minute examination of the specimens of *Palæobatrachus* at the Natural History Museum, which by the kindness of Dr. H. Woodward, F.R.S., I was allowed to make, failed to disclose any trace of the thyrohyals or the laryngeal skeleton.

In *Pipa* and *Xenopus* the third, fourth, and fifth digits of the hind limb are nearly equal in length, and in *Pipa* the third is if

anything longer than the fourth,—a feature unparalleled among living Anura (**23**. p. 178); and these facts acquire an exceptional significance when taken in conjunction with the observations of Wolterstorff, that in *Palæobatrachus* the third and fourth digits of the hind limb are either equal in length, or the third is but slightly shorter than the fourth (**43**. II. p. 16 [96], and I. p. 42). Further:—"Die Länge der Metacarpi, die stumpfe Beschaffenheit des Fusses haben *Palæobatrachus* und *Xenopus* mit *Pipa* gemeinsam" (**43**. II. p. 75).

Palæobatrachus is unique among Anura in having the diapophyses of the seventh, eighth, and ninth vertebræ confluent to form a disc, perforated by two foramina which mark the limits of the three diapophyses (**43**. p. 30). Among living Anura a multiple sacrum is only met with in *Pelobates* and *Pipa*, although it may occur exceptionally in the frog (Howes **21**) and *Bombinator* (Götte **17**; Camerano **5**). In *Pelobates* and *Pipa* the expanded plate to which the ilium is attached is formed by the united diapophyses of the ninth and tenth vertebræ; and in the late embryo of *Pipa* (Stage VI., *antea*) there is present near the posterior edge of the plate a small triangular foramen which marks off the small transverse process of the tenth vertebra from the expanded diapophysis of the true sacral (ninth) vertebra. The outlines of the ninth and tenth vertebræ cannot be distinguished with certainty in the adult. In both *Pelobates* and *Pipa* the urostyle is immovably fused with the sacrum *. In *Xenopus* also the sacral diapophyses are greatly expanded, and the urostyle is confluent with the sacrum. The sacrum, however, is simple, and the lateral plates consist of the diapophyses of the ninth vertebra only. The tenth vertebra is not differentiated in *Palæobatrachus*, but is included, as it is in most Anura, in the urostyle. This latter is not confluent with the sacral vertebra, but articulates (**43**. p. 29) on to a pair of condyles situated on the posterior surface of its centrum.

There are eight free presacral vertebræ in *Xenopus*, but in *Pipa* only seven, the first two vertebræ not being differentiated from one another. In *Palæobatrachus* also the first two vertebræ are confluent, and, since the seventh and eighth enter into the formation of the sacrum, there are but five free vertebræ. The

* Cope's statement (**6**. p. 98 and **7**. p. 252) that in *Pipa* the urostyle is simple and attached to a single condyle is, if not misleading, liable to misinterpretation.

vertebral column of *Pelodytes* does not differ materially from the normal. The first two vertebræ are not confluent as Cope states (6. p. 108).

In both *Xenopus* and *Pipa* the diapophyses of the third and fourth vertebræ are very long, and those of the fourth are terminated by a large backwardly-directed plate of cartilage. It has always been urged as an argument against associating the Aglossa with the Discoglossidæ, that the latter have free ribs on the second, third, and fourth vertebræ, while the former have no ribs. But in ripe embryos of *Pipa* (Stage VI., *antea*) the second and third diapophyses are segmented, and the peripheral portions correspond exactly with the second and third ribs of *Discoglossus*. The first diapophysis is short and unsegmented. The hinder of the two ribs is terminated by a backwardly-directed plate of cartilage. Both the ribs and the transverse processes proper are ossified, and the former are freely movable upon the latter. The remaining vertebræ have no autogenous ribs. In *Xenopus* larvæ (Stage II., *antea*) there are long, ossified, movable ribs attached to the third and fourth vertebræ, and a small pair to the second. The transverse processes are practically absent, so that the ribs arise directly from the neural arch. In larvæ of *Pelobates* and *Pelodytes* I have been unable to find ribs differentiated on the second, third, and fourth vertebræ, although I have examined four different stages of the former and three of the latter.

As already noted by von Ihering (Morph. Jahrb. vi. 1880, pp. 297–314) and Grönberg (**18.** p. 641), no trace of separation of the first vertebra into two parts can be detected in embryos of *Pipa*. But the fact of the first spinal nerve passing out *through* the neural arch, and the presence of but six other presacral vertebræ, point to the conclusion that two vertebræ are here represented. The occurrence in the embryo of diapophyses in connexion with this vertebra is a serious bar to the acceptance of the view propounded by von Ihering (*l. c.*) that in *Pipa* the second vertebra has been excalated, for in no anurous amphibian are diapophyses known to occur on the first vertebra.

In *Palæobatrachus* the vertebræ are sometimes procœlous and sometimes opisthocœlous. In *Pipa* and *Xenopus* they are opisthocœlous. But great importance cannot be attached to the characters of the articular surfaces of the centra, since it is a well-known fact (Dugès, **10.** p. 107, Pl. 4. fig. 33 ; Cope, **7.** p. 253 ;

Boulenger, 3. p. 432, and others) that in *Pelobates* and some other genera the intervertebral sphere may remain free in the adult, or may attach itself indifferently to the vertebra in front or that behind, causing them to become procœlous and opisthocœlous respectively. The extent of ossification of the frontoparietals is a character upon which Cope lays considerable stress in his classification. In *Pipa* and *Xenopus* the degree of ossification of the roof of the skull rather negatives their affinity with the Discoglossidæ, to which Cope (7. p. 248) considers them most nearly allied. The frontoparietal is strongly ossified in *Palæobatrachus*. In both *Pipa* and *Xenopus* the epicoracoid cartilages of the shoulder-girdle are in contact in the middle line, without overlapping or fusing, so that in this respect the Aglossa occupy a position intermediate between the Arcifera and the Firmisternia. There is no ossified xiphisternum, nor omosternum, and Cope regards the girdle, although a rigid one, as a modified variety of the arciferous type. Since the firmistern Anura are arciferous in early life, and since the girdle of *Pipa* and *Xenopus* cannot be conceived as originating by any modification of the raniform type, the probability of any affinity between the Aglossa and the firmistern Phaneroglossa is emphatically negatived.

In the limb skeleton the distal carpalia 3 and 4 are perfectly distinct in both *Xenopus* and *Pipa* (23. p. 161). This is a primitive character which brings the Aglossa near to *Pelobates* and the Discoglossidæ. But, on the other hand, the reduction of the skeleton of the pollex in *Xenopus* and *Pipa*, and the fusion of the second and third tarsalia of the distal row, are features indicating a degree of specialization not paralleled in the Discoglossidæ, *Pelobates* or *Pelodytes*. In the fusion of the ulnare with the postaxial centrale, *Pipa* differs not only from *Xenopus* but from all other Anura (23. p. 161). *Xenopus* possesses maxillary teeth, while *Pipa* is edentulous; but assuming that Cope is justified in discrediting the systematic value of the tooth-characters in Anura (7. p. 247), another great barrier between *Pipa* and *Xenopus* is broken down.

The extraordinary brood-pouches on the back of the female *Pipa* are not represented in *Xenopus*; but they cannot be regarded as of taxonomic importance, since brood-chambers of one kind or another are developed independently in widely-removed genera of Anura. The abnormality, amounting almost

to suppression, of the larval development in *Pipa* is of course directly related to the protected position which the embryos occupy on the back of the mother. The paired spiracular aperture of *Xenopus* larvæ is a primitive character, and the absence of a suctorial mouth with horny teeth shows less specialization than in more familiar tadpoles. The absence in *Pipa* and *Xenopus* of a persistent pre-renal part of the embryonic post-cardinal vein, which persists so frequently in the Discoglossidæ (22), is a sign of extensive departure from the primitive type. The epipubic cartilage of Urodela is represented in *Xenopus* by the racket-shaped cartilage in the postero-ventral body-wall; but it is not, so far as I am aware, found in any other Anura. It is not present in *Pipa*. In the retention also, by the adult, of the organs of the lateral line, and in the possession of claws on the first three digits of the hind foot, *Xenopus* is unique among Anura *.

In the characters of the shoulder-girdle, the genera *Pipa* and *Xenopus* would appear to be more closely allied to one another than to any of the Phaneroglossa †; and the characters of the muscular system recounted by Beddard, taken in conjunction with the anatomy of the hyobranchial apparatus set forth in the body of the present paper, and the features of the carpus and tarsus, tend in the main to show that, however much at variance they may be in many details of anatomical structure, the two genera, *Pipa* and *Xenopus*, have a true genetic relationship, and are not to be looked upon as the culminating members of parallel series. The suggestion of convergence put forward by Cope cannot yet be considered as finally disposed of, but the most recent evidence that has been brought to bear upon the question points towards a common ancestry of the two tongueless toads.

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* Since writing the above, Mr. G. A. Boulenger, F.R.S., has been good enough to demonstrate to me the presence of a persistent lateral line in *Leptobrachium monticola*, *Rana hexadactyla*, and various species of *Pseudis*, and has furnished me with a reference to his published allusion to the fact:—Ann. Mus. Genova (2), xiii. 1893, p. 344.

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EXPLANATION OF THE PLATES.

Plate 8.

Fig. 1. *Xenopus lævis*, female. Hyobranchial and laryngeal skeleton, ventral view. (×3.)

2. *Xenopus lævis*, female. Right half of laryngeal skeleton, seen from within. (×3.)
3. *Xenopus lævis*, female. Laryngeal skeleton, dorsal view. (×3.)
4. *Xenopus lævis*, male. Laryngeal skeleton, ventral view. (×2½.)
5. *Xenopus lævis*, male. Laryngeal skeleton, in median section. (×2½.)
6. *Xenopus lævis*, male. Laryngeal skeleton, dorsal view. (×2½.)

In figures 2 and 5 the cut surfaces are marked by diagonal shading.

Plate 9.

Fig. 1. *Pipa americana*, female. Hyobranchial and laryngeal skeleton, ventral view. (×3.)

2. *Pipa americana*, female. Laryngeal skeleton, dorsal view. (×3.)
3. *Pipa americana*, female. Laryngeal skeleton, median vertical section. (×3.)
4. *Pipa americana*, male. Internal or ventral view of the roof of the laryngeal skeleton, cut as indicated by the dotted line in fig. 6. (×1½.)
5. *Pipa americana*, male. Dorsal view of laryngeal skeleton after removal of the roof. (×1½.)
6. *Pipa americana*, male. Laryngeal skeleton, seen from the left side. The dotted line indicates the plane of section of figs. 4 and 5. (×1½.)
7. *Rana esculenta*, female. Right half of the laryngeal skeleton in median section. (×4.)

In figs. 3, 4, 5, and 7 the cut surfaces are marked by diagonal shading.

Reference letters to Plates 8 *and* 9.

a. Ala, or great wing of the hyobranchial skeleton.
ap. Antero-lateral process of the basal plate.
ar. Arytenoid cartilage.
ar'. Posteriorly-directed process of the arytenoid cartilage.
bl. Blinker-shaped process of the cricoid cartilage. ("Scheuklappenartiger Fortsatz" of Henle.)
br. Bronchial cartilage.
c. Dorsal or roofing portion of the cricoid cartilage.
c'. Antero-ventral portion of the cricoid cartilage.
c''. Postero-ventral portion of the cricoid cartilage.
ch. Ceratohyal or anterior cornu.
ch'. Median rod of cartilage formed by the union of the anterior cornua.
cr. Crest arising from the floor of the larynx.
d. Process of the arytenoid to which the dilator muscle is attached.
ep. Posterior epiphysis of the thyrohyal.
f. Membranous area in the side-wall of the larynx.
f'. Membranous area in the floor of the larynx.

g.e. Area of insertion of the m. geniohyoideus externus.
gl. Position of the glottis.
h. Hyoglossal foramen.
i. Isthmus between the anterior and posterior portions of the basal plate.
i'. Ligament in the male *Pipa* equivalent to the cartilaginous isthmus of the female.
l. Ligament in the male *Xenopus* equivalent to the cartilage, *z.* fig. 1, of the female.
l'. Ligament binding the cricoid cartilage to the posterior epiphysis of the thyrohyal.
pc. Procricoid.
r. Ring of cartilage surrounding the aperture of the lung.
t. Thyrohyal.
v. Surface of articulation between the arytenoid rod and the roof of the larynx.
vc. Rudimentary vocal cord.
x. Posterior limit of the basal plate of the hyobranchial skeleton.
y. Anterior border of the basal plate.
z. Bar of cartilage connecting the ala with the basal plate.

Plate 10.

Fig. 1. *Xenopus lævis*, female. Muscles of the ventral surface of the larynx. ($\times 2\frac{3}{4}$.)
2. *Xenopus lævis*, female. Muscles of the dorsal surface of the larynx. ($\times 2\frac{3}{4}$.)
3. *Xenopus lævis*, male. Muscles of the ventral surface of the larynx. ($\times 2\frac{1}{2}$.)
4. *Xenopus lævis*, male. Muscles of the dorsal surface of the larynx. ($\times 2\frac{1}{2}$.)
5. *Pipa americana*, female. Muscles of the dorsal surface of the larynx. ($\times 3\frac{1}{3}$.) At the top of the figure the three divisions of the hyoglossus are seen issuing through the hyoglossal foramen.
6. *Pipa americana*, female. Muscles of the ventral surface of the larynx. ($\times 3\frac{1}{2}$.)

Reference letters to Plate 10.

a. Area of insertion of an ill-defined muscular tissue.
b. Bronchus.
c. M. compressor glottidis.
d. M. dilator laryngis.
d'. Accessory slip of the dilator muscle.
d.a. M. dilator laryngis anterior.
g. Glottis.
g.i. M. geniohyoideus internus.
h.e. M. hyoglossus externus.
h.i. M. hyoglossus internus.
o.i. Laryngeal tract of the m. obliquus internus.
p. M. petrohyoideus.

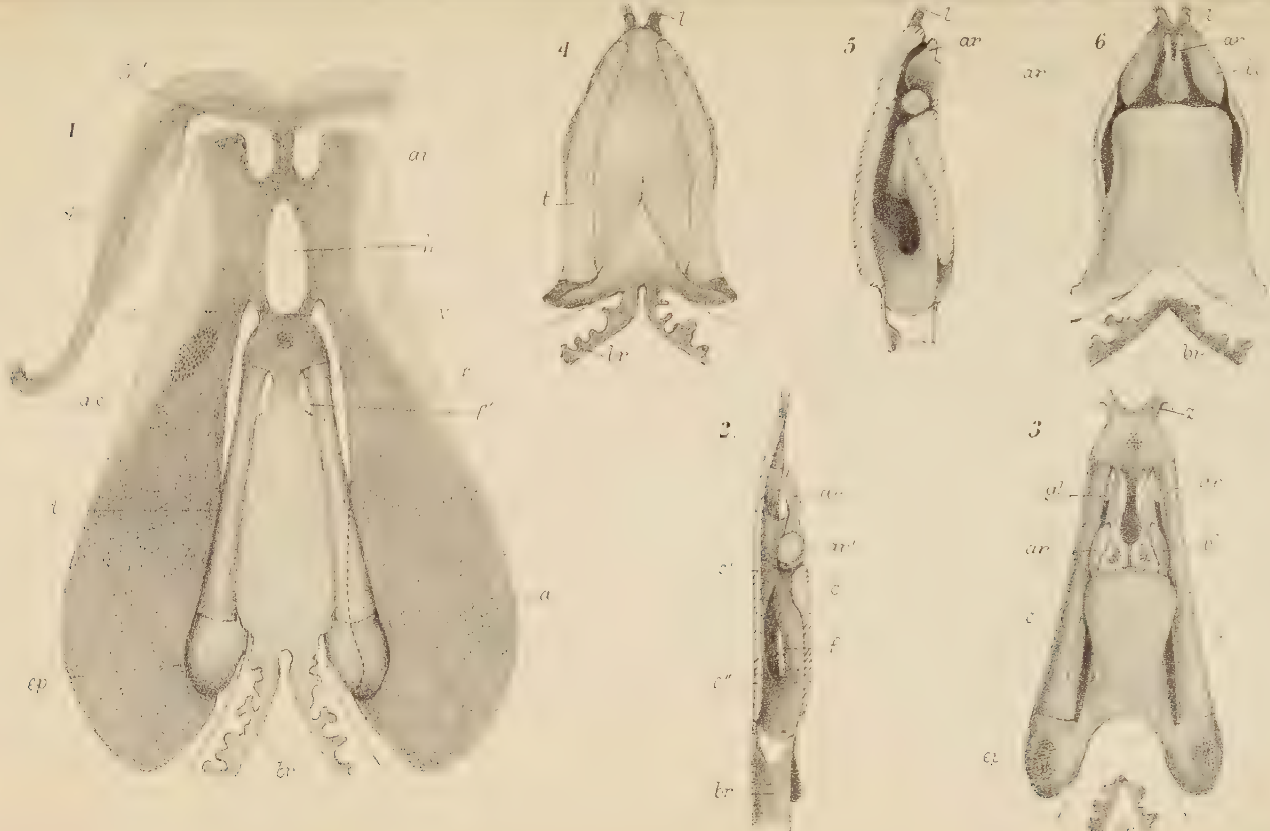
Plate 11.

Fig. 1. *Xenopus lævis*, larva, stage 1. Hyobranchial skeleton, with mandible and larynx. ($\times 3\frac{1}{2}$.) Dorsal view.

2. *Xenopus lævis*, larva, stage 2. Hyobranchial skeleton, with mandible and larynx. ($\times 4$.)
3. *Xenopus lævis*, larva, stage 3. Hyobranchial skeleton, with mandible and larynx. ($\times 6\frac{1}{2}$.)
4. *Pipa americana*, embryo, stage 1. Hyobranchial skeleton, with mandible and larynx. ($\times 8$.) Dorsal view.
5. *Pipa americana*, embryo, stage 2. Hyobranchial skeleton, with mandible and larynx. ($\times 7$.)
6. *Pipa americana*, embryo, stage 3. Hyobranchial skeleton, with mandible. ($\times 7$.)
7. *Pipa americana*, embryo, stage 4. Hyobranchial skeleton, with mandible. ($\times 6$.)
8. *Pipa americana*, embryo, stage 5. Hyobranchial skeleton, with mandible. ($\times 6$.)
9. *Pipa americana*, embryo, stage 6. Hyobranchial skeleton, with mandible. ($\times 6$.) The position of the larynx is indicated by the dotted line.
10. *Xenopus lævis*, larva, stage 3. Laryngeal skeleton, dorsal view. ($\times 12$.)
11. *Pipa americana*, embryo, stage 6. Laryngeal skeleton, dorsal view. ($\times 8$.)
12. Same, ventral view.
13. *Bombinator pachypus*, adult female. Laryngeal skeleton, dorsal view. ($\times 4\frac{1}{2}$.)

Reference letters to Plate 11.

a. Ala, or greater wing of the hyobranchial skeleton.
ar. Arytenoid cartilage.
b. Bronchus.
bh. Basihyal.
br. Bronchial cartilage.
cb.1. Ceratobranchial element of the first branchial arch.
ch. Ceratohyal.
ch'. Median rod of cartilage in front of the hyoglossal foramen.
cl.3. Third branchial cleft.
eb. Epibranchial or commissural cartilage.
g. Glottis.
g.e. Area of attachment of the m. geniohyoideus externus.
h. Hyoglossal foramen.
hb. Hypobranchial plate.
k. Overhanging cartilage on the antero-external edge of the branchial basket.
l'. Ligament connecting the cricoid cartilage and the posterior epiphysis of the thyrohyal.
m. Meckelian cartilage or mandible.
p. Accessory lobe of the lung arising from the dorsal surface of the bronchus.
t. Thyrohyal or posterior cornu.
t'. Thyroid foramen.
† Region of separation of the first ceratobranchial from the hypobranchial plate.



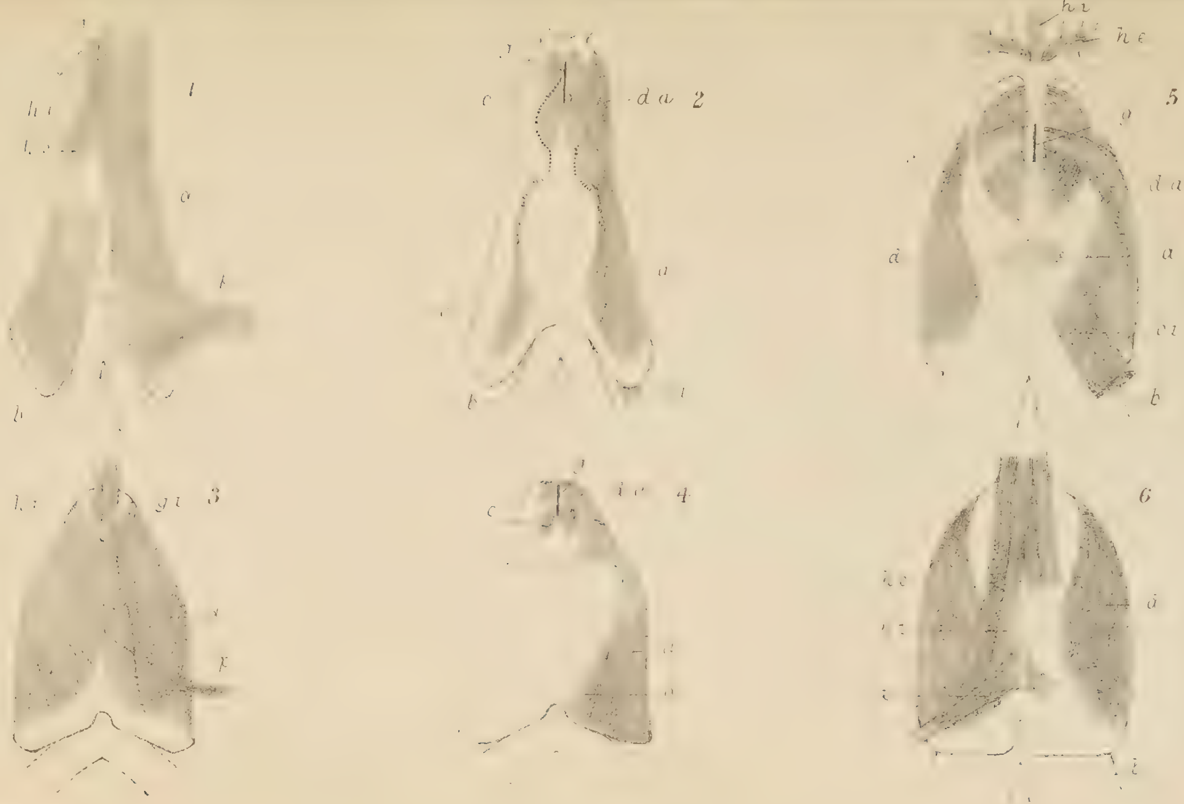
R. G. R. del. J. Green lith.
Mintern Bros. imp.

XENOPUS LÆVIS.

W. G. R. del. J. Green lith.

Mintern Bros. imp.

PIPA AMERICANA.



W. G. R. del. J. Green lith.

Mintern Bros. imp.

XENOPUS & PIPA.

W. G. R. del. J. Green lith.

Mintern Bros. imp.

XENOPUS & PIPA.

On the *Chalcididæ* of the Island of Grenada, B.W.I. By L. O. Howard, Ph.D., Entomologist to U.S. Department of Agriculture. (Communicated by F. DuCane Godman, F.R.S., F.L.S., on behalf of the Committee for Investigating the Flora and Fauna of the West-Indian Islands.)

[Read 17th December, 1896.]

Of the collection of parasitic Hymenoptera made by Mr. H. H. Smith on the Island of Grenada during the spring of 1891, under the auspices of the West India Committee, Mr. Ashmead has already reported upon the Ichneumonidæ, Braconidæ, Cynipidæ, and Proctotrypidæ, in the Proceedings of the Zoological Society of London, 1895, pp. 742–812. The Chalcididæ, forming the rest of the collection, are described in the following pages. The collection in this family was not a large one. Mr. Smith informs me that he made no especial effort to collect the insects of this group. There were, nevertheless, between six and seven hundred specimens, among which the writer has found 132 species, of which 72 are new and 60 have previously been described. Representatives of six new genera have also been found. The general facies of the collection is similar to that of the collection from St. Vincent, and the occurrence of 72 new species must not be taken to indicate that a large proportion of these species cannot also be found by careful collecting upon the Island of St. Vincent. Of the 60 previously-described species here recorded, 50 are known to occur also upon the Island of St. Vincent, 42 of them having been described for the first time in the companion paper on the parasitic Hymenoptera of St. Vincent, Linnean Journal, Zool., vol. xxv. Of the remainder, 4 are found in Cuba and Central America, 2 in Brazil, and 1 only in Florida and St. Vincent. Six are parasites of scale insects, and are likely to be carried to any country with their hosts on cultivated plants. All of these 6 are found in Florida, 1 only in Florida and Texas, 4 in the southern United States generally, 2 in California, 1 in Japan, and 1 in Italy, the last two having also been found in several localities in the United States. One (*Spalangia nigra*) is a common European parasite of the house-fly. This species is not abundant in the United States, and, in fact, I have seen it only from the West Indies.

The insects of this family are far too little known in their South and Central American and West Indian distribution to

suggest even the most tentative generalizations on the material studied. It is true that a number of Chalcididæ from Central America have been described by Mr. Cameron, but Mr. Smith's method of collecting differed so greatly from that of the naturalists engaged in collecting for the 'Biologia Centrali-Americana,' that it is not fair to generalize on the rather radical difference in character between the specimens studied by Mr. Cameron and those collected by Mr. Smith.

Family CHALCIDIDÆ.

Subfamily Chalcidinæ.

Spilochalcis, *Thomson.*

Spilochalcis femoratus.

Crabro femoratus, *Fabr. Syst. Ent.* p. 375, no. 10 (1775).

Sphex punctata, *Fabr. Spec. Ins.* i. p. 446 (1781).

? Chalcis fasciata, *Oliv. Enc. Méth.* v. p. 439, no. 9 (1790).

Smicra subpunctata, *Walk. Ent. Mag.* ii. p. 25 (1834).

Smicra nigropicta, *Cress. Proc. Ent. Soc. Phil.* iv. p. 55 (1865).

Smicra dorsivittata, *Cameron, Biol. Cent.-Am., Hym.* i. p. 90, pl. v. fig. 2.

Smicra femorata (*Fabr.*), *Kirby, Linn. Journ., Zool.* xvii. p. 66.

Spilochalcis femoratus (*Fabr.*), *Howard, Linn. Journ., Zool.* xxv. p. 79.

Mr. Smith took in all 27 male and female specimens of this species. They were captured under diverse conditions. Several came to light at night, others were flying at sunset about cocoa orchards, and others were found under decaying leaves on a damp rock. It is apparently a very abundant Indian and Central American species.

Spilochalcis fulvescens.

Smicra fulvescens, *Walker, Ent. Mag.* ii. p. 25.

Smicra fulvescens, *Walker, Cresson, Trans. Am. Ent. Soc.* iv. p. 56.

Spilochalcis fulvescens (*Walker*), *Howard, Linn. Journ., Zool.* xxv. p. 79.

There are 21 male and female specimens of this species from Grenada, exhibiting a great variation in size, and taken by Mr. Smith under the same diverse conditions as the preceding species.

Spilochalcis transitiva.

Smicra transitiva, *Walker, Trans. Ent. Soc. Lond.* ser. 3, v. i. p. 371 (E. Fla.).

Smicra pulchra, *Cresson, Proc. Ent. Soc. Phil.* iv. p. 94 (Cuba).
Smicra pulchra, *Cresson, Trans. Am. Ent. Soc.* iv. p. 50 (Mex. Can.).
Smicra transitiva, *Walker, Cresson, Trans. Am. Ent. Soc.* iv. p. 57 (E. Fla.).

A single male was taken by Mr. Smith, February 20, at an elevation of 250 feet, on the bank of a shady stream under decaying leaves on a damp rock. It should probably be separated generically from *Spilochalcis* on account of the femoral armature.

Smicra, *Spinola.*

Smicra Cressoni, sp. n.

♀. Length 3·6 mm.; expanse 5·2 mm. Scape of antennæ three-fourths as long as flagellum. Petiole more than twice as long as rest of the abdomen, and rather longer than the head and thorax together. Hind coxæ three-fourths as long as petiole. Head faintly shagreened in the ocellar space, longitudinally striate on the face; furnished with close short white pile each side of the insertion of the antennæ; antennal groove with a central carina below, reaching towards the top of the head as far as the middle of the groove; short, sparse, white hairs on lower face. Mesonotum delicately rugose transversely, almost aciculate. General colour black and honey-yellow. The centre of each of the thoracic sclerites black, margins yellow; head black above, lower face honey-yellow; margins of eyes and those of antennal groove yellowish; antennæ dark above, yellowish below; abdomen black above, yellowish on first segment, and another yellowish band a little before the middle; tip yellowish; petiole black; front and middle legs entirely pallid with a tinge of yellowish; hind coxæ honey-yellow below, black above, the black extending nearly to the lower side in an indefinite band on the distal third of the coxa; hind femora mottled, honey-yellow, blackish, and lighter yellow, the blackish predominating above; hind tibiæ yellowish with a darker central band. Femoral teeth 13 in number, small, dark in colour.

Described from three female specimens, one swept from herbage, April 7, elevation 250 feet, and the others taken under similar circumstances, April 25.

The species comes closest to *S. debilis* (Say), but differs in its longer scape and longer kind coxæ. It resembles rather closely *S. meteori* of the writer's manuscript, reared from *Meteorus hyphantriæ*, Riley, in the district of Columbia.

Chalcis, *Fabricius.*

Chalcis annulatus.

Chalcis annulatus, *Fabr. Ent. Syst.* ii. p. 197-9; *Syst. Piez.* p. 167.

Chalcis annulatus, *Fabr.*, *Howard* (redescription), *Linn. Journ., Zool.* xxv. p. 80.

Mr. Smith took 36 male and female specimens at many different spots.

Antrocephalus, *Kirby.*

Antrocephalus punctigerus.

Chalcis punctigera, *Fabr. Syst. Piez.* p. 167 (S. A.).

Antrocephalus punctigerus, *Howard, Linn. Journ., Zool.* xxv. p. 81.

Three male and four female specimens.

Notaspis, *Walker.*

Notaspis formiciformis.

Notaspis formiciformis, *Walker, Ent. Mag.* ii. p. 37 (St. Vincent).

Notaspis formiciformis, *Howard, Linn. Journ., Zool.* xxv. p. 83 (St. Vincent).

Mr. Smith took only a single male of this remarkable Chalcidid. It was captured at light at night.

Podagrion, *Spinola.*

Podagrion brasiliensis.

Podagrion brasiliensis, *Howard, Linn. Journ., Zool.* xxv. p. 83 (St. Vincent and Brazil).

Mr. Smith captured four females and one male at light at night and in the house on window.

Subfamily Eucharinæ.

Kapala, *Cameron.*

Kapala furcata.

Eucharis furcata, *Fabr. Syst. Piez.* p. 158.

Eucharis flabellata, *Fabr. l. c.*; *Walker, Entomologist,* i. pl. P. fig. 2.

Chirocerus furcatus, *Brullé, Nat. Hist. d. Ins., Hym.* iv. p. 571, t. 38. fig. 5.

Thoracantha furcata, *Hal. Entom.* i. pl. P. fig. 2.

Kapala furcata, *Cameron, Biol. Cent.-Am., Hym.* i. pl. v. fig. 17 (Costa Rica, Guatemala, Panama, S. C.).

Kapala furcata, *Howard, Linn. Journ., Zool.* xxv. p. 84 (St. Vincent).

One male, captured March 31, at an elevation of 1900 feet, on foliage near the ground, near water.

Stilbula, *Spinola.*

Stilbula grenadensis, n. sp.

♀. Length 1·8 mm.; expanse 5·3 mm. Scape very short; pedicel round; funicle-joint 1 very long and slender, 2 half as long as 1 and a little thicker, remaining joints gradually decreasing in length and of about the same thickness; club ovate, nearly twice as long as preceding joint. Face with strong, close, longitudinal fasciculæ; punctation nearly joining below insertion of antennæ, but separated by a well-rounded ridge; ocelli nearly in a straight line; middle ocellus very slightly advanced; mesoscutum with close hexagonal punctation; mesoscutellum with same punctation very much drawn out longitudinally. General colour honey-yellow; eyes reddish; head black above, brownish on lower face; abdomen dark brown, nearly black at tip; mesopleura brown; mesonotum with brownish markings defining parapsides and a brown stripe down centre of scutellum; scutellar projections blackish; antennal scape and pedicel light honey-yellow; flagellum darker; wings hyaline.

Described from one female specimen, Balthazar (windward side), 1900 feet elevation, on foliage on ground at a damp spot near water.

The species resembles closely *S. nigriceps* of Ashmead's MS., collected at Chapada, Brazil, by Mr. H. H. Smith. It is considerably smaller, and the markings are less vivid.

Orasema, *Cameron.*

Orasema Cameroni, sp. n.

♀. Length 1·9 mm.; expanse 4·4 mm. Head and face closely and rather finely punctate; disc of mesoscutum coarsely and transversely shagreened, parapsides smoother, with a close row of coarse punctures in dividing sutures; mesoscutellum coarsely shagreened longitudinally and with partial longitudinal striations; metanotum rugose; propleura nearly smooth, slightly shagreened towards head; mesopleura rather coarsely shagreened; petiole longitudinally striate; hind coxæ very faintly shagreened. Colour metallic blue-green, head and thorax greenish, with coppery reflections on scapulæ; abdomen bluish; antennal scape, all tibiæ and tarsi, and hind femora honey-yellow; flagellum of antennæ, all coxæ, and front and middle

femora, except at tips, brown, the front femora slightly metallic. Wings hyaline; wing-veins light brown.

One female, Balthazar, April 7, swept from herbage.

ORASEMA SMITHI, sp. n.

♀. Length 1·7 mm.; expanse 3·8 mm. Head and face closely and more finely punctate than in preceding species; entire mesonotum rather uniformly and closely punctate, a little more coarsely on mesoscutum than on head, and still more so on scutellum; metanotum rather coarsely punctate, subrugulose, propleura delicately aciculate; mesopleura closely and finely punctate; petiole finely granulate, not striate; hind coxæ faintly punctured. General colour uniform metallic blue; all coxæ metallic; scape and legs pallid, front and middle femora a little darker. Wings as with preceding species.

In the type specimens the enormous mandibles are widely extended, the left showing three teeth and the right four.

One female, Balthazar, April 7, swept from herbage.

Subfamily PERILAMPINÆ.

PERILAMPUS, *Latreille.*

PERILAMPUS POLITIFRONS.

Perilampus politifrons, *Howard, Linn. Journ., Zool.* xxv. p. 85 (St. Vincent).

Three males taken in the house on windows.

PERILAMPUS PARVUS, sp. n.

♀. Length 1·6 mm.; expanse 3·5 mm. Differs from *P. politifrons* mainly in sculpture of the mesonotum. Instead of close punctures, each umbilicate puncture is distinctly separated from its neighbours by a flattened space; the general surface delicately shagreened transversely between circular punctures; border of parapsides smooth; metanotal nucha not transversely striate but with several coarse longitudinal striations; occiput transversely aciculate; face smooth round insertion of antennæ. faintly shagreened on cheeks. General colour black, slightly metallic; flagellum of antennæ yellowish brown, pedicel darker; mandibles and all tibiæ brown; in other respects like *P. politifrons.*

One female, Mount Gay estate, April 1, 250 feet, taken in house on window.

Subfamily Torymінæ.

Idarnes, *Walker*.

Idarnes carme.

Idarnes carme, *Walker*, *Ann. & Mag. Nat. Hist.* xii. p. 47 (St. Vincent)

Five females, Balthazar, March 2 to April 15.

Colyastichus, *Mayr*.

Colyastichus flavus, sp. n.

♀. Length of body 0·88 mm.; ovipositor 0·35 mm.; expanse 1·8 mm. Antennal scape short, not reaching to middle ocellus; pedicel obconical, twice as long as wide; ring-joints plain; funicle-joints well separated, subequal in length and breadth, each about as broad as long, except terminal, which is slightly broader than long; club oval, flattened, about as long as three preceding funicle-joints together. Body slender, nearly smooth, shining, mesoscutum and scutellum very faintly shagreened longitudinally. General colour honey-yellow; ocelli reddish; flagellum of antennæ dark brown; mesoscutellum, dorsum of first and second abdominal segments, and ovipositor black. Wings hyaline, veins very light.

One female, Mount Gay estate, April, at light at night.

Syntomaspis, *Foerster*.

Syntomaspis punctifrons.

Syntomaspis punctifrons, *Ashmead*, *Linn. Journ., Zool.* xxv. p. 154, ♂ (St. Vincent).

Two females, Mount Gay estate, March 31, 1900 feet.

Torymus, *Dalman*.

Torymus ventralis, sp. n.

♂. Length 1·16 mm.; expanse 2·2 mm. Antennæ short; scape not reaching to middle ocellus; flagellum slightly longer than face; club strongly flattened. Head and thorax with fine squamose sculpture. General colour bright golden green with strong reflections; ocelli red; antennæ dark honey-yellow, scape and pedicel lighter than funicle, and club darker; legs pallid, including front coxæ, hind tibiæ darker; abdomen honey-yellow except for a large dark central spot above which extends down on sides to some extent. Wings hyaline, veins light brown.

Two males, Mount Gay estate, 250 feet, April 6 and 7, one on foliage in second-growth woods, and the other at light at night.

TORYMUS PALLIDIPES.

Torymus pallidipes, *Ashmead, Linn. Journ., Zool.* xxv. pp. 153–4, ♀ (St. Vincent).

One male of what is probably this species, Chantilly estate, April 6, 400 feet, high growth of weeds in young nutmeg orchard.

Subfamily EURYTOMINÆ.

ISOSOMODES, *Ashmead.*

ISOSOMODES GIGANTEA.

Isosoma gigantea, *Ashmead, Trans. Am. Ent. Soc.* xiii. 1886, p. 127 (Florida).

Isosomodes gigantea, *Ashmead, Linn. Journ., Zool.* xxv. p. 59 (St Vincent).

One female, Mount Gay estate, April 2, 1900 feet, upon shore of lake.

ASHMEADIA, *Howard.*

ASHMEADIA MEGASTIGMA.

Ashmeadia megastigma, *Ashmead, Linn. Journ., Zool.* xxv. p. 145 (St. Vincent).

Two females, one male, Mount Gay estate, April 1, sea-level, April 6, 250 feet; on foliage near road in dry second-growth woods.

ASHMEADIA PULCHRA.

Ashmeadia pulchra, *Ashmead, Linn. Journ., Zool.* xxv. p. 145 (St Vincent).

One male, Mount Gay estate, April 6, 250 feet, on road in dry second-growth woods on foliage.

ASHMEADIA COLLARIS, sp. n.

♂. Length 1·9 mm.; expanse 3·0 mm. Resembles *A. pulchra*, Ashmead; differs mainly in coloration. General colour yellowish white; disc of mesoscutum brownish; parapsides with brown centre; disc of mesoscutellum also brownish, in the form of a broad central stripe not reaching to tip; metanotum and petiole of abdomen, pleural sutures and border of hind coxæ, as well as broad stripe above and below abdomen, also brownish; occiput

nearly black; small blackish spot inclosing ocelli; antennal groove immediately at base of antennæ, blackish, and a brownish stripe from base of antennæ to clypeus. The most obvious colorational difference is in the fact that the pronotum is entirely yellowish and does not possess the four brown stripes characteristic of *pulchra*.

One female, Balthazar, March 5, 250 feet.

EVOXYSOMA, *Ashmead*.

EVOXYSOMA VITTATUM, sp. n.

♀. Length 3·2 mm.; expanse 4·3 mm. Antennæ with short scape, bulbous pedicel; funicle-joints 1 to 5 decreasing in length, joint 1 nearly twice as long as 2, club distinctly 2-jointed, terminal joint indistinct, as long as two preceding funicle-joints together; ocelli in curved line; head, pronotum, and mesonotum coarsely umbilicate-punctate; metanotum with a broad shallow central emarginate groove, the groove transversely striate; either side of groove umbilicate-punctate; abdomen smooth, shining, mesopleura distinctly and finely punctate; pilosity of mesonotum white, abundant on fore border; metanotal fimbria long, white; margin of joints 4 and 5 of abdomen with long whitish hairs; pygidium closely set with white pile. General colour reddish yellow; club of antennæ blackish; ocellar spot, border of occipital foramen, front of pronotum where impinging on head, parapsides and anterior border of disc of mesoscutum, all of metanotum, mesopleura, petiole, segments 1, 2, and 3 of abdomen, except for a lateral spot on each side of the centre of joint 3 above, stripe down centre of joint 4, margins of joints 5 and 6 and pygidium, black; eyes dark red; wing-veins brown; all legs honey-yellow; coxæ a little darker.

Described from one female, Balthazar, April 15, 250 feet, shady place near stream.

DECATOMIDEA, *Ashmead*.

DECATOMIDEA COMPACTUM, sp. n.

♀. Length 2·8 mm.; expanse 3·7 mm. Scape moderate; pedicel short, triangular; funicle-joints 1 to 5 subequal in length and breadth, each a trifle longer than pedicel; club long, ovate-acute, slightly flattened, longer than two preceding funicle-joints together; head, pro- and metanotum finely umbilicate-punctate;

ocelli forming a long curved line dividing the vertex into four subequal portions; anterior border of mesoscutum finely aciculate transversely; hind coxæ and mesopleura finely shagreened; metanotum rather coarsely rugoso-punctate; median furrow faintly indicated, apparently diverging anteriorly; entire surface of abdomen faintly shagreened; segment 4 practically including the later ones; 1, 2, and 3 subequal in length. Colour black, shining; all legs and all of antennæ honey-yellow; tip of pygidium also honey-yellow; pedicel of antennæ brownish; wing-veins yellow-brown.

Described from one female, Lake Antoine estate, March 24, swept from herbage.

Eurytoma, *Illiger*.

Eurytoma Cressoni, sp. n.

♀. Length 2·9 mm.; expanse 4·0 mm. Antennæ with short scape; short triangular pedicel; funicle-joint 1 distinctly longer than pedicel; joints 2, 3, 4, and 5 shorter than 1, very slightly increasing in width; club ovate, not acute, slightly wider than funicle-joint 6 and a little longer than 5 and 6 together; head, pro- and mesonotum closely and finely umbilicate-punctate, the pronotal articulating surface densely and finely shagreened; anterior articulating border of mesoscutum also finely shagreened transversely; mesopleura closely and finely punctate, smooth at dorsal posterior border; proximal portion of hind coxæ and all of abdomen closely and finely shagreened; metanotum with broad, semicircular, central portion, which is closely and finely punctate; this space surrounded by an irregular groove and at upper outer margin with two or three larger deeper punctures; on either side of this central space the sclerite is coarsely rugoso-punctate; metanotal fimbria dense and short; pygidial pubescence short and sparse. General colour black; antennæ dark brown; all legs, including front and middle coxæ, honey-yellow; hind coxæ blackish, with a yellowish longitudinal stripe above; venter of abdomen mahogany colour, this coloration extending dorsally to a considerable extent on apical half of fourth joint.

♂. Funicle-joints of antennæ regularly arched above, all subequal in length; club nearly twice as long as preceding joint, its first joint not well distinguished from the second; central space of metanotum much smaller than in female; petiole closely

and finely punctate; abdomen perfectly smooth, shining. Hind coxæ as well as remainder of all legs honey-yellow; abdomen with only a trace of the mahogany colour below at base.

Described from one female and one male specimen, Balthazar; the latter March 2, 250 feet, second-growth thicket; and the former April 5, 250 feet, open place on bush at sunset.

EURYTOMA WALSHI, sp. n.

♀. Length 2·9 mm.; expanse 4·0 mm. Differs from preceding species in colour and in the following structural characters:—Anterior articulating margin of mesoscutum densely and finely punctate, not transversely shagreened; mesopleura more coarsely punctate, with three longitudinal carinæ and the rather coarse sub-longitudinal punctures impinging upon each carina, finely granulate posteriorly; hind coxæ densely punctate; entire disc of metanotum closely and finely granulate; at anterior centre are two shallow foveæ forming apparently the beginning of a central groove: sides of the metanotum rugoso-punctate; abdomen perfectly smooth, not delicately shagreened. Colour black; antennæ very dark brown, nearly black; front and middle femora and tibiæ, and hind tibiæ, honey-yellow; all coxæ black, hind femora nearly all black, yellowish at either extremity; wing-veins light.

♂. Length 2·3 mm. Funicle-joints concave in the middle above, each appearing, therefore, double-humped, the hair-whorl given off at each hump; club distinctly 3-jointed, the basal joint not separated from the rest by a petiole; discal space of metanotum not so broad as with female. Colour like that of female, except that basal half of scape is honey-yellow; remainder of antennæ jet-black.

Described from six females and three males, Mount Gay estate, April 3, 250 feet, some swept from herbage, others taken in house on window.

EURYTOMA MAYRI, sp. n.

♀. Length 3·0 mm.; expanse 4·7 mm. Antennæ in proportion of joints resemble preceding species; articulating-surface of pronotum and mesoscutum finely shagreened transversely, the latter smooth at anterior margin; metanotum lacking the broad central disc; irregularly rugoso-punctate, with a faint indication of a central longitudinal furrow; coxæ closely punctured; mesopleura

closely and finely punctured; abdomen smooth, except segments 5 and 6 and pygidium, which are faintly shagreened; metanotal fimbria sparse, short. Colour black; antennal scape, all tibiæ and tarsi and middle femora honey-yellow; front and hind femora black; middle femora and hind tibiæ slightly brownish in centre; wing-veins dark brown.

♂. Length 2·3 mm. Funicle-joints 2 and 3 with moderate double humps, 1 and 4 not concave in the middle; basal joint of club set off with a distinct petiole from remainder of club. Colour as in female, except that front femora are honey-yellow.

Described from two females and two males, Granville, St. George's, and Mount Gay estates, March 1 to April 9; sea-shore to 250 feet, under varying conditions.

Subfamily Pireninæ.

Herbertia, *Howard.*

Herbertia lucens.

Herbertia lucens, *Howard, Linn. Journ., Zool.* xxv. p. 98.

One female specimen, Balthazar (windward side), swept from herbage near a stream.

Erotolepsia, *Howard.*

Erotolepsia compacta.

Erotolepsia compacta, *Howard, Linn. Journ., Zool.* xxv. p. 100.

One male, Mount Gay estate (leeward side), swampy forest near sea-shore.

Subfamily Spalangiinæ.

Spalangia, *Latreille.*

Spalangia nigra.

Spalangia nigra, *Latreille, Gen. Crust. et Ins.* iv. p. 29 (Europe).

Spalangia nigra, *Ashmead, Linn. Journ., Zool.* xxv. p. 57 (St. Vincent).

One male, Balthazar, April 15, 300 feet, shady spot near stream. A parasite of the house-fly in Europe.

Spalangia impuncta, n. sp.

♀. Length 1·58 mm.; expanse 2·4 mm. Head elongate, flattened, with a sharp median groove from anterior ocellus to clypeus; smooth, with a few very faint sparse punctures and sparse pubescence; eyes very hairy. Flagellum of antennæ a trifle more

than one-third longer than scape; first funicle-joint closely joined to pedicel; club as long as three preceding funicle-joints together. Pro- and mesonotum smooth, shining; scutellum with no transverse row of punctures; metanotum finely punctate at border, disc with a double row of punctures confluent behind. Petiole a little longer than hind coxæ, longitudinally aciculate. Colour black; tarsi whitish.

One female, Balthazar, March 5, 250 feet. Closely related to *S. drosophila*, Ashm., from Florida.

Subfamily Pteromalinæ.

Tribe *Chiropachides*.

Acrocormus, *Foerster*.

Acrocormus megastigmus.

Acrocormus megastigmus, *Ashmead, Linn. Journ., Zool.* xxv. p. 155 (St. Vincent).

One female, March 31 (Grand Étang), 1900 feet, on foliage near the ground, near water, damp.

Tribe *Sphegigastrides*.

Syntomopus, *Walker*.

Syntomopus incisoideus, n. sp.

♀. Length 2·2 mm.; expanse 3·6 mm. Head broader than thorax, oval from front, narrowly ellipsoidal from above; face plainly carinate below insertion of antennæ; ocelli forming a very obtuse-angled triangle, the lateral ones dividing the space between eyes into three equal parts; genal sulcus faintly indicated at border of eye. Antennæ inserted somewhat below middle of face, short; scape slender, not reaching to middle ocellus; funicle-joints transverse, except first, which is somewhat longer than broad; flagellum as a whole subclavate, club obtusely rounded. Thorax rather flattened above; metanotum with a complete central longitudinal carina, lateral carinæ distinct; petiole with two delicate longitudinal carinæ; abdomen behind petiole with a strong, large, oval depression. Head and thorax, including metanotum, all pleura, bases of coxæ, and petiole of abdomen closely punctate; abdomen smooth, shining. General colour metallic green, somewhat æneous on mesoscutum and scutellum, bluish on pleura and petiole; antennal scape brown,

flagellum black; all coxæ and femora metallic; tibiæ dark brown, yellowish at either end. Wings hyaline, veins light.

One female, Chantilly estate, 700 feet, March 14, on herbage in cocoa orchard.

Polycystus, *Westwood.*

Polycystus luteipes, sp. n.

♂. Length 1·6 mm.; expanse 3·1 mm. Head somewhat broader than thorax, when seen from above concave behind and convex in front; clypeal margin of face straight, cheeks very slightly rounded, genal sulcus very faint, entire; terminal joint of palpi as long as one-fourth width of head, nearly as broad as long. Antennæ inserted below middle of face, scape reaching above middle ocellus; pedicel twice as long as broad; ring-joints distinct; funicle-joints each a trifle longer than broad, cylindrical; club oval, flattened, as long as the two preceding funicle-joints together. Head, thorax, including pleura, and petiole of abdomen closely and finely punctate except metanotum, which, with middle and hind coxæ, is finely shagreened; abdomen smooth, shining. General colour bright bronze-green; scape and first five funicle-joints of antennæ, palpi, base of mandibles, and all legs except coxæ bright straw-coloured, almost orange; tips of mandibles, base of pedicel above, sixth funicle-joint, and all of club except extreme tip, brown. Wings hyaline; tegulæ and wings light brown.

Two males, one Balthazar, April 3, 250 feet, swept from herbage, and the other Mount Gay estate, April 6, 250 feet, road in dry second-growth woods, on foliage.

Polycystus nigritus, sp. n.

♀. Length 1·7 mm.; expanse 2·8 mm. Head considerably broader than thorax, very slightly convex in front and concave behind; clypeal margin and cheeks straight; genal sulcus indicated at margin of eyes only; palpi normal. Antennæ inserted just below middle of face; scape not reaching to middle ocellus; pedicel slightly longer than broad; funicle-joint 1 one half longer than broad, remaining funicle-joints decreasing slightly in length and increasing very slightly in width; club pointed, ovate, very nearly as long as two preceding funicle-joints together. Punctation as with preceding species, except that metanotum is finely punctate, with pronounced median carina and smooth

nucha. Thorax above and top of head with sparse white scaly pile. General colour black, slightly glistening and faintly metallic in some lights; antennal scape, tegulæ, all trochanters, tips of femora, and all tibiæ light brown. Wings hyaline, veins light brown.

Three females, Balthazar and Mount Gay estate, April 3–10, 250 feet, one taken in house on window and the others swept from herbage.

POLYCYSTUS NIGRISCAPUS, sp. n.

♀. Length 1·7 mm.; expanse 2·9 mm. Differs from *P. nigritus* in the following particulars:—Head only slightly broader than thorax; cheeks rounded; genal sulcus not indistinct. Antennæ inserted far below middle of face; pedicel twice as long as wide; funicle shortened, joints 5 and 6 considerably wider than long; club oval, flattened, as long as three preceding funicle-joints together. Metanotal characters cannot be made out in the single badly-mounted specimen. Thorax with no scaly pile. Antennal scape black, yellowish at extreme base.

One female, Mount Gay estate, 250 feet, April 6, in dry second-growth woods on foliage.

Tribe *Mischogastrides.*

HALTICOPTERA, *Spinola.*

HALTICOPTERA SUBPETIOLATA, sp. n.

♂. Length 2·2 mm.; expanse 4·0 mm. Head subtriangular; petiole distinct, rugose, twice as long as wide; head broader than pronotum; head, pro- and mesonotum closely and finely punctulate; metanotum finely shagreened, with distinct median and lateral carinæ; petiole closely punctate, with distinct and complete dorsal median longitudinal carina, and with anterior and median lateral projections; abdomen smooth, glistening. Antennæ rather stout; scape reaching to middle ocellus; ring-joints distinct; funicle-joint 1 stouter but shorter than pedicel, about as long as broad; remaining funicle-joints subequal in length, but increasing very slightly in width; club oval, flattened. Thorax convex; second segment of abdomen longer than all others together. General colour metallic green; head and thorax dull metallic green except hind margin of pronotum and except metanotum, which are bright and glistening; abdomen

with brilliant reflections; antennæ rather dark brown, scape rather lighter than flagellum; tegulæ light brown; all legs uniformly honey-yellow.

One male, Mount Gay estate, April 1, swampy forest near sea-shore.

Tribe *Diparides*.

Lelaps, *Haliday*.

Lelaps pulchricornis.

Lelaps pulchricornis, *Haliday MS., fide Walker, Ann. & Mag. Nat. Hist.* ser. 1, xii. p. 47, ♀ (St. Vincent).

Lelaps pulchricornis, *Ashmead, Linn. Journ., Zool.* xxv. p. 156, ♂ ♀ (St. Vincent).

Twenty-three males and females, Grand Étang, Balthazar, Mt. Maitland, and Mirabeau estate, March 2 to April 5, 250 to 1900 feet, under varying conditions, usually near streams.

Lelaps flavescens.

Lelaps flavescens, *Ashmead, Linn. Journ., Zool.* xxv. p. 156, ♂ ♀ (St. Vincent).

Nine males and females, seven Balthazar, one Mt. Maitland, and one Mirabeau estate; those at Balthazar collected June 11, 250 feet, flying at sunset after heavy rain.

Tribe *Pteromalides*.

Pteromalus, *Swed.*

Pteromalus rugosopunctatus.

Pteromalus rugosopunctatus, *Ashmead, Linn. Journ., Zool.* xxv. p. 165, ♂ ♀ (St. Vincent).

Many males and females, collected under varying conditions at different points.

Spintherus, *Thomson*.

Spintherus dubius.

Spintherus dubius, *Ashmead, Linn. Journ., Zool.* xxv. p. 159, ♀ (St. Vincent).

Two females, Chantilly estate, April 6, 400 feet, high growth of weeds in nutmeg orchard.

The species is doubtfully placed in *Spintherus* by Mr. Ashmead.

MERAPORUS, *Walker*.

MERAPORUS NIGROCYANEUS.

Meraporus nigrocyaneus, *Ashmead, Linn. Journ., Zool.* xxv. p. 159, ♂ (St. Vincent).

Two males, Balthazar, March 5 and May 2, 250 feet.

GLYPHE, *Walker*.

GLYPHE PUNCTATA.

Glyphe punctata, *Ashmead, Linn. Journ., Zool.* xxv. p. 162, ♀ (St. Vincent).

One female, Balthazar, April 3, 250 feet, swept from herbage.

CATOLACCUS, *Thomson*.

CATOLACCUS VULGARIS.

Catolaccus vulgaris, *Ashmead, Linn. Journ., Zool.* xxv. p. 164, ♂ ♀ (St. Vincent).

Many specimens of both sexes from a number of localities, taken under varying conditions.

CATOLACCUS CARINATUS, sp. n.

♂ ♀. Closely resembles *C. vulgaris*, but differs quite markedly in metanotal structure. In *C. vulgaris* the metascutellum has a faint median longitudinal carina which sometimes is simply a slight rounded elevation, the nucha not especially differentiated, and the whole sclerite finely punctate except at posterior border. In the present species the median longitudinal carina is sharp and pronounced and the nucha, which is as long as the body of the sclerite, is differentiated by a transverse slightly arched carina. The whole sclerite is delicately transversely shagreened. The antennal flagellum is black and longer than in *C. vulgaris*, and the punctation of the thorax somewhat finer.

Three females, Mount Gay estate and St. George's, March 2 to April 10, 250–300 feet—one at light at night, one under rotting weeds, and one in house on window.

Subfamily EUPELMINÆ.

EUPELMUS, *Dalman*.

EUPELMUS PALLIDIPES.

Eupelmus pallidipes, *Ashmead, in manuscript supplement to Report on the Parasitic Hymenoptera of St. Vincent.*

One female, Balthazar, April 3, 250 feet, swept from herbage.

EUPELMUS RETICULATUS, sp. n.

♂. Length 2·3 mm.; expanse 4·0 mm. Antennæ short, subclavate, club flattened; funicle-joints club-shaped, subequal except 1, which is smaller. Eyes strongly hairy, distant. Head finely rugoso-punctate; mesonotum reticulate, reticulations of scutellum finer than on scutum; pronotum imbricate-punctate; metanotal carina complete, stout, lateral spaces smooth, shining; pleura and outer side of hind coxæ finely reticulate; abdomen smooth, but with very many short dark hairs on posterior two-thirds. Colour metallic blue-green; head steel-blue; pleura purplish; legs light reddish brown, hind femora metallic on outer third, hind tibiæ dark at tip; antennal scape concolorous with legs; flagellum black; wings hyaline, veins dark brown, nearly black.

Two males, Mount Gay estate, April 6, 400 feet, high growth of weeds in young nutmeg orchard.

Subfamily ENCYRTINÆ.

ÆNASIUS, *Walker*.

ÆNASIUS HYETTUS.

Encyrtus hyettus, *Walker, Ann. Mag. Nat. Hist.* xvii. (1846) p. 881. St. Vincent.

Ænasius hyettus, *Howard, Linn. Journ., Zool.* xxv. (1894) p. 89. St. Vincent.

Six females, three males, Granville, Mount Gay estate, and Balthazar, all on trailing plants growing on sand at the sea-shore, except the Mount Gay estate specimen, which was taken in the house on window.

TANAONEURA, gen. nov.

♀. Antennæ 11-jointed with an additional ring-joint, inserted at middle of face; scape slender; pedicel short; funicle-joints subequal in length and width, each nearly twice as long as pedicel. Facial depression moderate, carina short, sharp; eyes distinct, ocelli at corners of a very obtuse-angled triangle; occipital margin somewhat rounded. Thorax elevated, metanotum abruptly declivous; legs stout, front femora somewhat swollen; middle tibial spur rather short. Wings ample; marginal vein one-third as long as submarginal; stigmal very long, longer than marginal, postmarginal slightly longer than stigmal, marginal

somewhat thickened, postmarginal nearly as thick as marginal. Abdomen short, ovipositor slightly extruded.

TANAONEURA ASHMEADI, sp. n.

♀. Length 1·7 mm.; expanse 3·8 mm. Antennal club shorter than two preceding funicle-joints together. Face finely shagreened and with moderately large, dense punctures; mesoscutum rugulose, opaque, scutellum finely shagreened; mesopleura longitudinally aciculate towards dorsal margin, smooth and shining ventrally; abdomen smooth, shining; axillæ meet at tips. General colour black, without metallic lustre; antennal scape, all tibiæ and tarsi and all trochanters honey-yellow; all femora black; wings hyaline, veins dark yellow-brown.

One female, Mirabeau estate, March 25, 500 feet, on herbage near stream.

BOTHRIOTHORAX, *Ratzeburg*.

BOTHRIOTHORAX INSULARIS, sp. n.

♀. Length 2·1 mm.; expanse 3·4 mm. Axillæ just meet at tips. Punctures of head large, close and round; punctures of mesoscutum somewhat elongate and shallower posteriorly; axillæ smooth, shining; scutellum rounded at tip, not at all emarginate, smooth, shining, with a faint trace of striations at cephalic margin; mesopleura very faintly shagreened; head and mesonotum with moderately strong and sparse black hairs, the six or eight at tip of scutellum bending toward head and apparently tending slightly towards the formation of a scutellar tuft. Eyes faintly hairy. Joint 1 of antennal funicle a little longer than pedicel; joint 2 shorter than 1; remaining joints subequal in length but increasing in width to club which is ovate, not obliquely truncate as with most species, and as long as two preceding funicle-joints together; flagellum densely clothed with short hairs, which however do not obscure the joints. General colour black, with faint metallic reflections; antennal scape, apical half of middle tibiæ, all of front tibiæ, and all tarsi honey-yellow.

♂. Antennæ moniliform; relative length of joints about as in female, which it resembles in other respects.

Described from four females and three males, Mount Gay estate and Chantilly estate, nearly all 400 feet, in young nutmeg orchard in high growth of weeds.

CHILONEURUS, *Westwood.*

CHILONEURUS FUNICULUS, sp. n.

♀. Length 1·7 mm.; expanse 3·2 mm. An interesting form which seems intermediate between *Comys* and *Chiloneurus*, and for which the generic characters of *Chiloneurus* must be extended to include forms in which the first funicle-joint is longer than pedicel. Scape long, slender; pedicel short, triangular; funicle-joint 1 twice as long as pedicel and nearly three times as long as thick; joints 3, 4, 5, and 6 each rapidly broadening and becoming shorter, 5 wider than long; club (broken off in type-specimen). Eyes moderately approximate; ocelli at angles of a slightly acute-angled triangle. Head closely and finely shagreened; mesoscutum with closely appressed silvery hairs; axillæ meeting at tips; mesoscutellum very finely punctate, opaque; mesoscutellar tuft strong and black; metanotum shining, metallic, fimbria strong; mesopleura faintly shagreened. Marginal vein somewhat longer than stigmal; stigmal and post-marginal very short, separated by a very narrow angle and of nearly equal length; stigmal, if anything, slightly longer: below submarginal is a hyaline transverse band, rest of the wing fuscous, lighter at extreme tip; on fuscous portion discal cilia very dense, with a slight oblique hairless band below marginal vein, extending proximally to hyaline band; cilia costad of this streak stronger than elsewhere on disc. Colour variegated: scape, antennæ, front coxæ, tibiæ and femora, middle femora and hind coxæ honey-yellow; flagellum of antennæ black; head and face brownish, with faint metallic reflections; mesoscutum black, colour obscured by the silvery pubescence; axillæ light brown; scutellum with its anterior half dull light yellow, posterior half brown; metanotum metallic green; mesopleura brown, with metallic greenish and purplish reflections; abdomen brown, with brilliant metallic green spot above at base; middle coxæ and tibiæ and hind femora and tibiæ nearly black; front and hind tarsi brown, middle tarsi honey-yellow; front tibiæ on upper side with a narrow metallic longitudinal stripe.

Described from one female specimen, St. John's River, March 27, 250 feet, cocoa orchard.

CHILONEURUS NIGRESCENS, sp. n.

♀. Length 1·4 mm.; expanse 2·6 mm. Belongs to the same group as the preceding species. Antennæ very distant at in-

sertion; antennal depression very broad, and distinguished by a curved line above; scape slender, short, shorter than in preceding species; pedicel moderate, triangular; funicle-joint 1 equal in length and width to pedicel, joints 2 to 6 increasing rapidly in width to club, subequal in length; club broad, flattened, nearly as long as three preceding funicle-joints together. Eyes approximate; ocelli very small, at angles of an acute-angled triangle. Pronotum with golden pubescence; mesonotum with close silvery pubescence; scutellar tuft extremely long, longer than scutellum itself, black in colour. Marginal vein longer than stigmal, very thick; stigmal and postmarginal extremely short, the former a little longer than the latter, which is almost wanting; angle between the two fully 45 degrees: the whole surface of the fore wing rather deeply infuscated, with hyaline stripe near base and a similar hairless streak below marginal vein; beginning of a faint hyaline transverse streak at tip of stigmal. Lower part of face smooth, front finely shagreened, vertex smooth; mesopleura finely shagreened. General colour black, shining; more or less metallic purplish reflections on face below, on mesopleura, mesonotum, and abdomen; mesoscutellum and axillæ dark brown; middle coxæ black, front and hind coxæ brown; hind femora and tibiæ black, front femora and tibiæ brown, middle femora and tibiæ brown, femora lighter than tibiæ; tarsi whitish.

One female specimen, Balthazar, April 7, 250 feet, in weedy place near stream.

Comys, *Foerster.*

Comys bicolor.

Comys bicolor, *Howard, Ann. Rep. U.S. Dept. Agric.* 1880, p. 362. District of Columbia.

Two females, Balthazar, April 7, 250 feet, open weedy place. One specimen is much darker than the other, and than the type-specimen from the district of Columbia; it is not, however, to be separated structurally.

Leptomastix, *Foerster.*

Leptomastix dactylopii.

Leptomastix dactylopii, *Howard, Bull. 5, Div. Entom. U.S. Dept Agric.* 1885, pp. 23–24. District of Columbia.

Leptomastix dactylopii, *Howard, Linn. Journ., Zool.* xxv. p. 92. St. Vincent.

One male, Balthazar, April 7, 250 feet, open woody place; and one female, Chantilly estate, April 6, 400 feet, in high growth of weeds in young nutmeg orchard.

BLASTOTHRIX, *Mayr.*

BLASTOTHRIX INSOLITUS, sp. n.

♀. Length 1·35 mm.; expanse 2·7 mm. Scape inserted at border of mouth, furnished with a broad leaf-like expansion below; pedicel subcylindrical, longer than first funicle-joint; funicle-joints 1 to 6 longer than wide, subcylindrical, increasing slightly in width; club somewhat flattened, oval, nearly as long as three preceding funicle-joints together; ocelli forming a slightly acute-angled triangle; axillæ slightly separated at tips. Marginal vein distinct, as long as stigmal, postmarginal apparently lacking; stigmal entering disc of wing at broad angle. Head and mesonotum densely, closely, and very finely punctate, not glistening; scape black, except for a white band near tip; pedicel black at base, elsewhere white; funicle-joint 1 black, remaining funicle-joints and club yellowish white; head and mesothorax dark orange-yellow; pronotum of same colour, but covered with dense whitish pile; the same whitish pile occurs on mesonotum, but is sparse; abdomen and metanotum black above, abdomen somewhat yellowish below; all legs yellowish white; wings milky, veins dark brown.

Described from one female specimen, Granville, April 9, on trailing plant growing on sea-shore.

APHYCUS, *Mayr.*

APHYCUS FLAVUS.

Aphycus flavus, *Howard, Ann. Rep. U.S. Dept. Agric.* 1880, p. 365. Palatka, Fla.

One female, Balthazar, April 7, 250 feet, on herbage near stream. There is a series of specimens of this species in the U.S. National Museum from Brownsville, Texas.

APHYCUS AMŒNUS, sp. n.

♂. Length 0·88 mm.; expanse 2·0 mm. Scape broadly widened below, the widening abrupt at tip; pedicel longer than broad; funicle-joints 1 to 4 almost moniliform, of equal length and width, 5 to 6 broader, subequal in length and width; club slightly flattened, oval, not wider than funicle-joint 6, and a

little longer than 5 and 6 together; vertex broad; ocelli large and brilliantly coloured, forming a slightly acute-angled triangle. General colour orange-yellow; scape black, white at extreme tip; pedicel black at base, white at tip; remainder of flagellum dusky; pronotum with a whitish border and a distinct black spot at each shoulder; tegulæ dirty white; abdomen and metanotum black above, the abdomen with black centre below, whitish at sides; all legs and pleura dirty white; wings hyaline, veins dusky.

One male, Balthazar, June 11, 250 feet, flying at sunset after heavy rain.

ENCYRTUS, *Dalman.*

ENCYRTUS SUBMETALLICUS, sp. n.

♀. Length 1·0 mm.; expanse 2·2 mm. Scape long, slender, not expanded, reaching to middle ocellus; flagellum subcylindrical; pedicel three times as long as broad; first funicle-joint about half as long as pedicel, remaining funicle-joints subequal in length, each slightly longer than joint 1 and increasing almost imperceptibly in width; club long ovate, not wider than funicle-joint 6, flattened from side, plainly divided into three equal joints and nearly as long as three preceding funicle-joints together; funicle-joints slightly hairy. Head semicircular in profile; antennæ distant at base; facial depression triangular; eyes approximate, naked; ocelli rather close together, forming a nearly right-angled triangle; thorax nearly flat, mesoscutellum slightly elevated; axillæ well separated at tips; vertex very finely shagreened, mesoscutum rather more coarsely shagreened; mesoscutellum densely and finely punctate, except at posterior border which is smooth; mesopleura smooth, shining; abdomen smooth. Fore wings rather narrow, marginal vein very short, postmarginal lacking; stigmal very short; wings hyaline, with a yellow-brown cloud below stigmal, extending backwards nearly to base of wing. General colour black, slightly metallic; head piceous, mesoscutum with slight greenish reflections, mesoscutellum with bronzy reflections, mesopleura with purplish reflections; underside of abdomen, all legs, and scape of antennæ below light honey-yellow; scape above and flagellum brown.

Three females, Chantilly estate and Balthazar, April 6, 400 feet, on high weeds in young nutmeg orchard; April 7, 250 feet, near stream.

ENCYRTUS MODERATUS, sp. n.

♀. Length 0·93 mm.; expanse 1·8 mm. Scape of antennæ slightly swollen, short; pedicel triangular, twice as long as broad; funicle-joints 1 to 3 together as long as pedicel, each broader than long, slightly widening from 1 to 3; 4, 5, and 6 each longer than preceding joint and slightly widening; club long ovate, flattened, nearly as long as funicle. Head wedge-shaped from side, vertex flattened; facial depression large, triangular, occupying almost entire face; eyes approximate, naked; ocelli small, forming a nearly right-angled triangle; thorax somewhat tectiform, the scuto-scutellar furrow forming the ridge; axillæ meeting at tips; vertex nearly smooth, glistening; mesoscutum faintly shagreened, scutellum very finely and uniformly punctate; axillæ faintly transversely aciculate; abdomen smooth, shining; mesopleura faintly aciculate, shining. Wings moderately broad; marginal vein distinct but short, postmarginal very short, stigmal very faint, almost indistinguishable; wings perfectly hyaline, veins almost colourless except marginal vein, which is heavy and brown; terebra slightly exserted. General colour black, with coppery reflections on mesopleura, faint bluish reflections on mesoscutum, greenish on head; all antennæ and all legs except hind femora honey-yellow; hind femora dark brown; hind coxæ dark at immediate base.

Three females, Balthazar and St. John's River, March 4, 250 feet, shady damp ditch; April 5, 250 feet, open place on bushes at sunset; April 7, 250 feet, herbage near stream.

ENCYRTUS CONFORMIS, sp. n.

♀. Length 1·77 mm.; expanse 3·3 mm. Body stout, thorax very convex; axillæ meeting at tips; scutellum rounded; abdomen cordate, flattened above. Antennæ short, rather stout, inserted just below middle of face; scape short, cylindrical; pedicel and first funicle-joint subequal in length; remaining funicle-joints subequal in length, each about as long as broad, but each somewhat shorter than 1; club oval, slightly flattened, shorter than two preceding funicle-joints together; entire flagellum with short close hairs. Eyes distinct, naked; ocelli forming a very obtuse-angled triangle. Head and face delicately reticulate, with sparse large round punctures at border of eyes and near ocelli; entire mesonotum delicately imbricate-punctate; metanotum not carinate; pleura very faintly longitudinally reticulate,

shining; abdomen smooth, shining. General colour black, with faint metallic reflections; coxæ and base of femora dark brown, rest of legs honey-yellow; tegulæ brown; antennæ honey-yellow, brownish towards tip; wings hyaline, veins very light.

♂. What may be the male of this species differs as follows:— The round punctures at vertex are more numerous; the meso-scutellum is closely and finely punctate; the antennæ about as with *E. convergens*, but dark brown in colour. Eyes sparsely hairy. Colour more metallic than in female.

One female, Balthazar, March 31, 1900 feet, on foliage on ground near water. One male, Mount Gay estate, April 1, swampy forest.

Encyrtus convexus, sp. n.

♂. Length 1·16 mm.; expanse 2·4 mm. Slender, dorsum of thorax strongly rounded in all directions. Antennal scape long, slender, cylindrical; pedicel very short, subglobose; funicle-joints decreasing slightly in length, joint 1 four times as long as broad, subcylindrical, well separated, each with sparse long hairs not arranged in whorls; club not widened, slightly longer than preceding funicle-joint. Eyes naked, distant. Mesonotum short; scutellum rounded; axillæ meeting at tips; abdomen tri-angular, flattened from above. Head and face finely transversely reticulate; cheeks smooth, shining; mesoscutum finely reticulate; axillæ smooth; mesoscutellum densely and strongly punctate, the impressions becoming lengthened around the border; metanotum smooth, with a complete median carina; mesopleura very delicately longitudinally reticulate. General colour metallic green; pleura and abdomen piceous; antennæ and mouth-parts light brown; all legs, including coxæ, light honey-yellow; wings hyaline, veins brown.

One male, Balthazar, March 31, 1900 feet, on foliage on ground, near water.

Encyrtus sordidus, sp. n.

♀. Length 0·86 mm.; expanse 2·7 mm. Body stout, short; thorax well arched; axillæ meeting at tips; abdomen subcircular. Eyes longitudinal, hairy, well separated; ocelli forming a right-angled triangle. Antennæ inserted below middle of face, short, clavate; scape short, slender, cylindrical; pedicel stout, rather more than twice as long as broad; first funicle-joint minute, trans-verse; remaining funicle-joints increasing in width to 6, which is

rather more than twice as wide as long; club flattened ovate, as long as four preceding funicle-joints together; entire flagellum with close short hairs, slightly appressed; mesoscutum and base of mesoscutellum very faintly reticulate, tip of scutellum perfectly smooth; metanotum not carinate, smooth; mesopleura and abdomen smooth, shining. Marginal vein of fore wings thickened, as long as stigmal, which enters disc of wing at a narrow angle with costa. General colour sordid black, slightly lustrous on scutellum, mesopleura, and abdomen; legs with dark femora and reddish-brown tibiæ and tarsi; antennal scape, pedicel, and end of club light brown, rest black; fore wings faintly and nearly uniformly infuscated.

One female, Grand Étang, March 31, 1900 feet, on foliage on ground, near water.

Encyrtus rotundiformis, sp. n.

♀. Length 1 mm.; expanse 1·9 mm. Body stout; thorax globular; abdomen subcircular. Scape slender, cylindrical, inserted near mouth and not reaching to middle ocellus; pedicel twice as long as first funicle-joint; funicle-joints increasing gradually in length and width, each about as wide as long; club slightly flattened, long oval, as long as three preceding funicle-joints together. Eyes faintly hairy, moderately distant; ocelli forming a right-angled triangle. Axillæ meeting at tips. Marginal vein of fore wings extremely short. Head finely rugose-punctate, becoming aciculate on cheeks; mesoscutum finely imbricate; mesoscutellum closely and deeply longitudinally aciculate; mesopleura nearly smooth, very faintly reticulate; abdomen smooth, shining. Colour: mesoscutum and mesopleura bright golden green; mesoscutellum dull opaque dark green; head dark greenish above, purplish below; abdomen dark, with greenish æneous reflections; all femora black, yellowish at each end; front and middle tibiæ and all tarsi light honey-yellow; hind tibiæ with basal half black; antennal scape black, light brown at extreme tip; remainder of antennæ brown. Wings hyaline, iridescent, veins brown.

Two females, Balthazar, and Mirabeau estate, April 5 and 6, 400 and 250 feet.

Archinus, gen. nov.

Antennæ inserted near mouth; scape long, slender, cylindrical; bulla cylindrical, one-fourth as long as scape; pedicel

longer than wide; funicle-joints all transverse: club very long, longer than entire funicle, stout, obliquely truncate from tip nearly to base. Eyes naked, approximate; ocelli forming a very acute-angled triangle. Mesonotum subtectiform; scutellum triangular; axillæ very narrow and widely separated at tips. Abdomen short, triangular on longitudinal section; ovipositor extruded. Fore wings ample, marginal vein extremely short; stigmal entering disc of wing at an angle of about 40° with costa; disc closely and finely ciliate, with a narrow oblique hairless streak below stigma.

ARCHINUS OCCUPATUS, sp. n.

♀. Length (less ovipositor) 0·88 mm.; expanse 1·9 mm. Scape reaching to middle ocellus; pedicel three times as long as broad and nearly as long as funicle; club longer than entire funicle and nearly as long as funicle and pedicel together. Head smooth, not highly polished; mesoscutum very faintly transversely shagreened and with sparse punctures; hind border of pronotum with several deep round punctures; mesoscutellum and abdomen smooth, scutellum opaque, abdomen not highly polished. General colour black, more or less shining; coxæ and femora jet-black, femora whitish at each end; basal half of front and hind tibiæ black, distal half light yellow; middle tibiæ with two sharp black bands, one at base and one at middle, elsewhere light yellow, as are also all tarsi; antennal scape brown, darker above; pedicel with basal half black, distal half yellowish; funicle-joints 1, 5 and 6 yellow, 2, 3, and 4 black; basal joint of club black, remaining joints light yellow-brown; ovipositor-sheaths black, yellow at tip, ovipositor honey-yellow. Wings hyaline, iridescent, veins brown, marginal darker.

One female, Balthazar, March 2, 250 feet, flying at sunset.

ARATUS, gen. nov.

♂. Head broad; cheeks prominent, genal sulcus absent; eyes distant, hairy; vertex with large round punctures, extended in a single row down inner border of eyes. Mesoscutum rather sparsely punctate; mesoscutellum smooth; axillæ meeting at tips. Hind legs unusually stout. Marginal vein of fore wings very short, postmarginal shorter than stigmal. Antennal scape short, cylindrical; pedicel shorter and narrower than first funicle-joint; flagellum stout, with very short hairs; funicle-joints all

nearly as broad as long and subequal in length and breadth; club oval, of same width as funicle-joint 6. Comes nearest to *Bothriothorax*.

♀ unknown.

ARATUS SCUTELLATUS, sp. n.

♂. Length 1·6 mm.; expanse 3·3 mm. Lower face and cheeks smooth, shining, face faintly reticulate; ocelli forming a right-angled triangle; punctation of mesoscutum not dense, impressions longitudinal, each deep anteriorly, becoming more and more shallow posteriorly; axillæ with a few small sparse round punctures; mesoscutellum and abdomen highly polished; mesopleura opaque, metapleura shining, faintly reticulate. Colour black; face with purplish reflections; mesoscutum with faint greenish lustre; mesoscutellum and metapleura æneous; all femora black, brown at tips; front and middle tibiæ light brown; hind tibiæ dark brown, light at tip; antennæ and mouth-parts light brown. Wings hyaline, veins brown, marginal vein darker.

One male, Mount Gay estate, April 1, swampy forest near sea-shore.

Subfamily APHELININÆ.

APHELINUS, *Dalman*.

APHELINUS DIASPIDIS, *Howard*.

Aphelinus diaspidis, *Howard, Ann. Rep. U.S. Dept. Agric.* 1880, p. 355. Ft. George, Fla., Santa Barbara, Cal., and Japan.

One female, Balthazar, April 13, 350 feet, in second growth on shores of stream.

ASPIDIOTIPHAGUS, *Howard*.

ASPIDIOTIPHAGUS CITRINUS.

Coccophagus citrinus, *Craw, Destructive Insects*, Sacramento, Cal., 1891. San Gabriel, Cal.

Aspidiotiphagus citrinus, *Howard, Insect Life*, vi. p. 234 (1891). San Gabriel, Cal.

Aspidiotiphagus citrinus, *Howard, Revision of the Aphelininæ of North America*, p. 31 (1895). San Gabriel, Cal., Champaign, Ill., and Portici, Italy.

One female, Balthazar, April 7, 250 feet, swept from herbage near stream.

Ablerus, *Howard.*

Ablerus clisiocampæ.

Centrodora clisiocampæ, *Ashmead, Proc. Ent. Soc. Wash.* iii. p. 10 (1894). Florida.

Ablerus clisiocampæ, *Howard, Revision of the Aphelininæ of North America,* p. 42 (1895). Dist. of Columbia; Champaign, Ill.

One female, Balthazar, 1900 feet, on foliage on ground.

Ablerus aureonotus, sp. n.

♀. Length 0·58 mm.; expanse 1·35 mm. Eyes red; pronotum and tip of abdomen black; base of abdomen light yellow; mesonotum golden yellow; legs uniformly dull honey-yellow; wings slightly infuscated, paler at tips; wing-veins dark brown; antennæ (broken except for the scape and 3 pedicel and 3 funicle-joints of the right one) uniformly honey-yellow.

Described from one female in poor condition, Balthazar, 300 feet, shady bank of stream.

Subfamily Elasminæ.

Elasmus, *Westwood.*

Elasmus Smithii.

Elasmus Smithii, *Howard, Linn. Journ., Zool.* xxv. pp. 104–5. St. Vincent.

Four females taken in April in the house on windows.

Elasmus flavoscutellatus, sp. n.

♀. Length 1·7 mm.; expanse 3·5 mm.; greatest width of fore wing 0·39 mm. Comes closest to *E. Smithii,* from which it differs mainly in the possession of a rather broad, semicircular yellow band around the posterior margin of the mesoscutellum. General colour dark metallic green; antennæ dark brown; front femora and tibiæ honey-yellow; front coxæ metallic at base, middle coxæ honey-yellow, hind coxæ metallic except at tip; middle and hind femora metallic above and with a broad median transverse dark band; middle tibiæ honey-yellow; dark lines of hind tibiæ forming four cells, one long and one short, covering the length of the sclerite, and two short ones to the outside; all tarsi black; tegulæ yellow at tip; semicircular band around apical border of mesoscutellum and all of mesopostscutellum yellow; abdomen dark above and yellowish below, the dark upper colour having a tendency towards extending down on the

sides in bands; tip of pygidium and terebra black. Abdomen longer than thorax; closed wings reaching exactly to tip of abdomen.

Described from two females swept from herbage April 3, at an elevation of 250 feet.

Elasmus cellulatus, sp. n.

♂. Length 1·4 mm.; expanse 3 mm.; greatest width of fore wing 0·36 mm. Head with close, rather small thimble-like punctures. General colour dark metallic blue-green; antennæ light brown; tip of all coxæ, all of front and middle tibiæ, base and tip of middle and hind femora pallid; all tarsi dark; tegulæ metallic; no trace of yellow on scutellum or postscutellum; dark lines of hind tibiæ arranged in two longitudinal rows of interfitting cells, three and a half cells to each row. Abdomen shorter than thorax; closed wings extending considerably beyond tip.

Described from one male taken on stones of stream April 13, at 350 feet elevation.

Elasmus levifrons.

Elasmus levifrons, *Howard, Linn. Journ., Zool.* xxv. pp. 101–102. St. Vincent.

One female, April 3, Balthazar, 250 feet, swept from herbage.

Subfamily Elachistinæ.

Euplectrus, *Westwood.*

Euplectrus furnius.

Euplectrus furnius, *Walker, Ann. Mag. Nat. Hist.* ser. 1, xii. p. 48 (=bicolor, *Swed.*). St. Vincent.

Euplectrus furnius, *Howard, Linn. Journ., Zool.* xxv. p. 105. St. Vincent.

Eleven males and females, Balthazar, Chantilly estate, and Grand Étang (windward side), and Mount Gay estate and St. George's (leeward side), captured under varying conditions. The species is probably parasitic upon noctuid larvæ.

Hoplocrepis, *Ashmead.*

Hoplocrepis grenadensis, sp. n.

♀. Resembles the type-specimen of this hitherto monotypical genus except in the following particulars:—The thorax instead

of being pale brownish yellow is a rather dark brown, and the abdomen is nearly black. The petiole instead of being white is brown. The wing maculation is as follows:—At proximal third of fore wing a narrow band arises from within the bunch of bristles and extends transversely to hind border, gradually widening; distad of this brown band is a hyaline band of about the same width, but wider at costa and narrower at hind border, instead of the reverse; beyond this the wing is brown to apex except for two roundish hyaline patches, one on costal margin just before apex and the other in a corresponding position on hind margin.

Described from one female, from which unfortunately the head is absent. Mount Gay estate (leeward side), swept from herbage near a stream.

PACHYSCAPHA, gen. nov.

♂. Scape of antenna inserted near the mouth by a short slender stalk and almost immediately widening enormously in a dorso-ventral direction, becoming nearly as wide as long, and presenting when seen from side the outline of a rounded triangle with its apex at pedicel; its inner surface is concave and its outer convex; pedicel short, triangular, twice as long as wide; funicle-joints subequal in length, each about as long as pedicel, moniliform; club long ovate, slightly wider than last funicle-joint but nearly twice as long. Face concave, occipital margin and pronotum faintly emarginate; scutellum without furrows. Abdomen with a distinct but short petiole. Posterior tibiæ with two long spurs, as with *Euplectrus*, with which it agrees in other respects.

PACHYSCAPHA INSULARIS, sp. n.

♂. Length 1·6 mm.; expanse 2·9 mm. Head and thorax with sparse long white bristles; mesoscutum with a rather coarse but shallow and irregular favose sculpture; mesoscutellum delicately longitudinally shagreened; pleura faintly granulate. General colour black, shining; antennal bulla, pedicel, and first funicle-joint and petioles of other joints, tegulæ, all legs including coxæ, and a broad triangular basal abdominal spot, honey-yellow; wings perfectly hyaline, veins slightly yellowish.

Described from six specimens, Balthazar, Mount Gay estate, and St. John's River—two in a cocoa orchard, two on foliage in second-growth woods, one in house on window, and one swept from herbage in open weedy spot.

Miotropis, *Thomson.*

Miotropis nigricans.

Miotropis nigricans, *Howard, Linn. Journ., Zool.* xxv. p. 106. St. Vincent.

Five females, one March 23, 500 feet, and the others April 3, 250 feet, open sandy places, swept from herbage.

Miotropis gibbosus, sp. n.

♀. Length 2·2 mm.; expanse 3·5 mm. Flagellum of antennæ moderately long, not condensed as with preceding species; funicle-joints a little longer than broad, well separated, club as long as last funicle-joint; eyes hairy, widely separated; ocelli in a curved line; mesonotum finely rugulose; scutellum smooth at sides; abdomen rather coarsely reticulate. General colour black; face, including cheeks, antennal scape, sides of pronotum, attenuated portion of collar, basal joint of abdomen, and all legs except hind coxæ, dark honey-yellow; wings hyaline, except for small dusky patch below and including stigmal vein.

One female specimen, Mount Gay estate, April 6, 400 feet, on high growth of weeds in young nutmeg orchard.

Stenomesius, *Westwood.*

Stenomesius histrionicus, sp. n.

♂. Length 2·1 mm.; expanse 3·3 mm. Antennæ with flagellar joints subequal in length, well separated, flattened, with dense short pile. Head and thorax nearly smooth, faintly shagreened; abdomen smooth, shining; median furrow of metanotum complete, sharp, slightly emarginate. Colour black; head honey-yellow, except occiput and eyes and closely placed reddish ocelli; mesoscutellum, parapsides of mesoscutum, and hind border of pronotum honey-yellow; dorsum of abdomen with pallid central basal spot, as with many species of *Elachistus*; basal portion of underside of abdomen also pallid; front coxæ yellow-brown, middle and hind coxæ dark above, all femora pale yellowish; hind tibiæ black except at base, middle and front tibiæ yellowish; wings hyaline.

One male specimen, April 1, Granville (windward side), sea-level, below somewhat swampy thicket by stream.

STENOMESIUS GRENADENSIS, sp. n.

♀. Antennæ with funicle-joints subequal in length, increasing slightly in width; pedicel smaller and narrower than funicle-joint 1; club slightly broader and longer than funicle-joint 4, ovate-acuminate; mesoscutum transversely aciculate, meso-scutellum smooth and shining; eyes widely separated, naked; ocelli forming a nearly right-angled triangle. General colour honey-yellow; metanotum black; wings hyaline; hairs on thorax dark.

One female specimen, Balthazar (windward side), March 31, 1900 feet, on foliage on ground, damp spot. The abdomen of the single specimen has been lost, but the form is characteristically marked.

ELACHISTUS, *Spinola.*

ELACHISTUS METALLICUS, sp. n.

♀. Length 1·5 mm.; expanse 2·8 mm. Facial depression broad, shallow, acute at apex; antennæ inserted below middle of face; scape short, not reaching middle ocellus; flagellum short, submoniliform; club ovate, longer than preceding funicle-joint. Head smooth, shining, with a few very faint punctures towards vertex; pronotum and mesoscutum transversely rugose, with long whitish hairs; mesoscutellum faintly reticulate, shining, with no trace of median furrow; abdomen smooth, shining; metanotum smooth, its median groove widening anteriorly. General colour metallic blue-green; antennæ dark honey-yellow; legs including coxæ light honey-yellow; abdomen with second joint honey-yellow above and with a large yellowish spot below; wings hyaline, stigmal vein slender.

One female specimen, Balthazar, March 31, 1900 feet, on foliage near ground.

ELACHISTUS SCUTELLATUS.

Elachistus scutellatus, *Howard, Linn. Journ., Zool.* xxv. pp. 107–108. St. Vincent.

Two males, one St. George's, March 2, 250 feet; and one Mount Gay estate, April 1, 250 feet, taken in house on window.

ARDALUS, gen. nov.

♀. Abdomen with a short but distinct petiole; scutellum with two longitudinal sutures; posterior tibiæ with two moderate

spurs, one longer than the other; eyes hairy; antennæ inserted below middle of face, scape short; pedicel short; four well separated funicle-joints, club ovate; occipital angle sharp; pronotum subconical; parapsidal sutures complete but delicate; axillæ strong; postmarginal vein much longer than stigmal, marginal still longer.

In this genus may be placed *Diglyphus*? *albipes*, Ashm., and *Diglyphus*? *maculipennis*, Ashm. (Linn. Journ., Zool. xxv. p. 167), described from St. Vincent.

Ardalus aciculatus, sp. n.

♀. Length 1·5 mm.; expanse 3·0 mm. Head smooth, shining, with small sparse round punctures; funicle-joints of antennæ flattened, subquadrate, each one half longer than broad, pubescent; pronotum and mesoscutum finely rugose; mesoscutellum and axillæ longitudinally aciculate; mesoscutellar sutures sharp, punctate at bottom, parallel; metanotal suture complete, emarginate; abdomen smooth, shining. General colour black; eyes reddish and ocelli bright red; scape, tegulæ, all legs except hind coxæ, base of abdomen above, and more than half of venter honey-yellow; wings hyaline.

Four female specimens, St. John's River, March 15, 250 feet, came to light at night, March 30; Mount Gay estate, April 1; Balthazar, April 7.

Ardalus politus, sp. n.

♀. Length 1·8 mm.; expanse 2·7 mm. Head and face shagreened, and with many rather large roundish punctures; first and second funicle-joints of antennæ long ellipsoidal, more than twice as long as broad, subequal, 3 and 4 considerably shorter and somewhat broader, cup-shaped, very faintly pubescent; pronotum and mesoscutum strongly shagreened; mesoscutellum and axillæ smooth; mesoscutellar sutures converging slightly towards head, with a row of punctures at proximal border; metanotum with central longitudinal carina; abdomen smooth, shining. General colour greenish æneous; all legs, including coxæ, pallid; scape pallid, flagellum light brown; wings with an irregular, somewhat circular discal fuscous patch.

One female, Balthazar, April 7, 250 feet, open weedy spot near stream.

Ardalus levigatus, sp. n.

♀. Length 1·3 mm.; expanse 1·75 mm. Head and face smooth, shining; mesonotum very faintly reticulate, appearing smooth and shining with a hand-lens; scutellar sutures converging somewhat towards head, punctate on inner border. Abdomen elongate ovate, longer than thorax, pointed, smooth and shining; segments 1 and 6 longest, 2, 3, 4, and 5 subequal, 2 a trifle the longest. Antennæ short; funicle-joints and club somewhat flattened, hairy; funicle-joints gradually shorter from 1 to 4, 4 as long as wide; club a little longer than two preceding funicle-joints together. Colour black, shining; antennal scape and all tibiæ and tarsi, and venter of abdomen at base light brown; femora and tips of coxæ darker, trochanters concolorous with tibiæ; fore wings with a distinct dark brown patch arising at stigmal vein and extending halfway across wing; veins dark brown.

One female, Mount Gay estate, April, 250 feet, in house on window.

Subfamily Eulophinæ.

Eulophus, *Geoffroy*.

Eulophus auripunctatus.

Eulophus auripunctatus, *Ashmead, Linn. Journ., Zool.* xxv. p. 166, ♀. St. Vincent.

One female, Balthazar, March 31, 1900 feet, on foliage near the ground, damp spot. It is unfortunate that we do not know the male of this very beautiful Eulophine, as it may prove the species to be distinct from *Eulophus*.

Paraolinx, *Ashmead*.

Paraolinx lineatifrons.

Paraolinx lineatifrons, *Ashmead, Linn. Journ., Zool.* xxv. p. 166, ♂ ♀. St. Vincent.

Four males, Balthazar, March 2, 250 feet, and March 31, 1900 feet, herbage.

Sympiesis, *Foerster*.

Sympiesis grenadensis, sp. n.

♀. Length 1·5 mm.; expanse 2·9 mm. Antennæ rather short, scape very slender; funicle-joints cylindrical, three times as long as wide, clothed with short erect hairs. Ocelli at angles of a

right-angled triangle; head smooth in ocellar space, faintly shagreened elsewhere; mesonotum closely and finely punctate; metanotum still more finely and somewhat longitudinally punctate, central longitudinal carina complete and distinct; abdomen broad oval, as wide as thorax and nearly as long. General colour bright golden green; head steel-blue above, with æneous reflections on face below; abdomen greenish at base, darker, with æneous reflections towards tip; pleura and coxæ purplish; all legs and antennal scape pallid, flagellum black; wings hyaline, veins light brown.

♂. Resembles the female in all details as above, except that abdomen is slender and nearly parallel-sided.

Three females, one male, Mirabeau estate, Balthazar, St. John's Bay, and Chantilly estate, March 25 to April 1, 250 feet, damp places.

Sympiesis politus, sp. n.

♀. Closely related to the preceding species, from which it differs only in the following particulars. Mesonotum instead of being closely and finely punctate is smooth, polished, with very faint shagreening. Antennal scape black; funicle-joints shorter in proportion to their length, not quite twice as long as wide. Abdomen long oval, a trifle longer than thorax, sides slightly flattened, subparallel in middle.

One female, Balthazar, April 3, 250 feet, open weedy spot, swept from herbage.

Necremnus, *Thomson*.

Necremnus purpureus, sp. n.

♀. Length 0·84 mm.; expanse 1·63 mm. Antennæ short, rather closely set with moderately long hairs. Body stout; abdomen short oval, a trifle wider than thorax and also a little shorter; ovipositor slightly extruded. Head and mesonotum with close fine round punctures; mesoscutellum with fine, shallow, somewhat elongate punctation; abdomen smooth. Wings reaching slightly beyond tip of abdomen, strongly ciliate, distal border narrowly brown; disc below and including stigmal vein with a brown transverse band darkest towards costa. General colour dark metallic purple, with green reflections on scutellum; legs pallid, middle and hind femora brownish at middle;

ovipositor light brown; antennæ black, last funicle-joint white, club brown.

One female, Balthazar, April 2, on trailing plant on sea-shore. Probably parasitic on some lepidopterous leaf-miner.

Subfamily Entedoninæ.

Omphale, *Haliday*.

Omphale varicolor.

Omphale varicolor, *Ashmead, Linn. Journ., Zool.* xxv. p. 168. St. Vincent.

Eighteen males and females, Mirabeau, Chantilly, and Mount Gay estates, Balthazar, and St. George's, March 1 to April 7, 250 to 400 feet, at light at night, in house on window, and swept from herbage under varying conditions.

Omphale striata, sp. n.

♀. Length 2·3 mm.; expanse 3·5 mm. Antennæ as with preceding species; mesonotum closely and finely punctate; metanotum smooth; abdomen finely shagreened; face faintly shagreened, with many short white bristles below; facial depression strong, antennal carina distinct, genal sulcus indicated faintly at border of eye; occiput delicately transversely aciculate. Colour metallic blue-green, the green predominating on dorsum of thorax and basal segments of abdomen, the blue on head, underside of body, and terminal three-fourths of abdomen; disc of mesoscutum with light green longitudinal stripe down centre bordered on each side by a darker and broader stripe, lighter again beyond; faint indication of similar marking on mesoscutellum; parapsides of mesoscutum also faintly striped in the same way; scape of antennæ brown; tips of tibiæ and all tarsi, except terminal joints, yellowish white; wings hyaline, veins nearly white.

♂. Extremely variable in size and colour. The stripe on mesoscutellum more pronounced than in female; hairs on flagellar joints very long, those on first funicle-joint nearly one-third the length of entire flagellum. Genal sulcus distinct, complete.

Described from seventeen male and female specimens, Mirabeau, Chantilly, and Lake Antoine estates, Balthazar, Grand Étang, March 2 to April 7, 250 feet, taken under varying conditions.

HOLCOPELTE, *Foerster*.

HOLCOPELTE NIGROCYANEUS.

Holcopelte nigrocyaneus, *Ashmead, Linn. Journ., Zool.* xxv. p. 171. St. Vincent.

Eleven males and females, Chantilly, Mirabeau, and Mount Gay estates, Balthazar, under varying conditions.

HOLCOPELTE METALLICUS.

Holcopelte metallicus, *Ashmead, Linn. Journ., Zool.* xxv. pp. 170–171. St. Vincent.

Eight male and female specimens, Mount Gay, Chantilly and Mirabeau estates, Balthazar, under varying conditions.

HOLCOPELTE NIGROÆNEUS.

Holcopelte nigroæneus, *Ashmead, Linn. Journ., Zool.* xxv. p. 172. St. Vincent.

Seven male and female specimens, Mirabeau and Mount Gay estates, St. John's River and Balthazar, under varying conditions.

HOLCOPELTE CUPREUS.

Holcopelte cupreus, *Ashmead, Linn. Journ., Zool.* xxv. pp. 171–172. St. Vincent.

Four females, one male, Mount Gay estate, Balthazar, and St. John's River, March 4 to April 10, 250 feet, came to light, taken in house on window, swept.

DEROSTENUS, *Westwood*.

DEROSTENUS ROTUNDUS.

Derostenus rotundus, *Ashmead, Linn. Journ., Zool.* xxv. p. 174. St. Vincent.

Eight male and female specimens, Mirabeau and Mount Gay estates, Balzathar, under varying conditions.

DEROSTENUS VIOLACEUS, sp. n.*

♀. Length 1·0 mm.; expanse 1·95 mm. Head faintly shagreened; pro- and mesonotum rather strongly shagreeno-punctate; first funicle-joint of antennæ as long as pedicel, joint 2 shorter than 1, joint 3 as long as 1 and broader, 4 equal to 3; club flattened, ovate, nearly as long as two preceding joints together; wings hyaline. Colour dark violaceous; antennæ, all tibiæ and tarsi, and middle femora light honey-yellow; front and hind femora brown above and in middle, yellowish at each end.

* This species belongs to the genus *Closterocerus*.—L. O. H.

Described from one female, Balthazar, March 31, 1900 feet, on foliage on ground.

ASTICHUS, *Foerster*.

ASTICHUS CILIATUS, sp. n.

♂. Length 0·81 mm.; expanse 1·6 mm. Scape inserted slightly below middle of face, reaching to tip of head; pedicel short, triangular; first and second funicle-joints subequal in length and only slightly separated by a petiole; second and third and third and fourth widely separated by a long petiole, the body of each joint crowned by four long hairs; club long ovate, with many long hairs. Head and face very delicately punctate, pro- and mesonotum rather more coarsely and very closely punctate; abdomen smooth; postmarginal and stigmal veins subequal in length, margin of fore wings uniformly furnished with rather long cilia. Colour metallic green, with æneous reflections on head and mesoscutum, and cupreous reflections on mesoscutellum; scape dark brownish; front legs yellowish white, middle and hind femora black at base, trochanters yellow, hind tibiæ black at extreme tip; front and middle tarsi cannot be seen, but hind tarsi have joint 1 white, joints 2 and 3 black, and joint 4 white. Front wings with three irregular dusky patches, one arising at middle of marginal vein and extending in the shape of an irregular band across the wing; the second arises at stigma and extends half way across; the third is a somewhat wedge-shaped spot at apex, the base of the wedge on the border of the wing; veins nearly white except for three black patches, one at base of marginal vein, one at middle of marginal vein, and one at tip of marginal vein, including stigmal.

Described from one male specimen, Grand Étang, 1900 feet, on foliage on ground.

CHRYSOCHARIS, *Foerster*.

CHRYSOCHARIS LIVIDICEPS.

Chrysocharis lividiceps, *Ashmead, Linn. Journ., Zool.* xxv. p. 176. St. Vincent.

One female, Mirabeau estate, 400 feet, brushed from herbage about cocoa orchard.

CHRYSOCHARIS FULGENS, sp. n.

♀. Length 1·16 mm.; expanse 1·95 mm. Head (badly

shrivelled) faintly punctate; eyes distinct, naked; mesonotum delicately shagreened; abdomen longer than thorax, ovate, strongly concave above, smooth, shining; bristles of mesonotum white, sparse and long. Colour of head and abdomen metallic blue-green with purplish reflections; thorax brilliant æneous; antennæ dark brown, all legs except coxæ pallid; wings perfectly hyaline, veins light green.

Described from one female, Balthazar, April 3, 250 feet, swept.

Entedon, *Dalman*.

Entedon pulcher, sp. n.

♀. Length 1·16 mm.; expanse 1·8 mm. Antennæ inserted between mouth and middle of face; scape short, not reaching to top of head; flagellum about as long as scape, joints short, condensed; club as long as funicle, prolonged into a stylus; head (greatly shrivelled) and mesonotum finely and closely punctate; abdomen faintly shagreened. Antennæ black, except club which is brown; head, mesoscutar parapsides, metanotum, abdomen, and entire underside of body dark metallic blue or purpureous; disc of mesoscutum brilliant æneous; scutellum brilliant cupreous; wings hyaline, with a narrow curved fuscous band below stigma, concave distally; distal tip of wing also narrowly fuscous; veins dark brown, stigma darker; legs black except at joints, tarsi nearly white.

One female specimen, Balthazar, April 9, sea-shore, on trailing plant.

Subfamily Tetrastichinæ.

Tetrastichus, *Haliday*.

Table of Grenada Species.

Females.

Abdomen ovate, nearly circular on cross-section, a trifle longer than thorax.
 Mesoscutum with several rows of impressed dots on medial side of parapsidal grooves........ *cupreus*, Ashm.
 Mesoscutum without such impressed dots.
  Scutellum without a median furrow.......... *cuproideus*, sp. n.
  Scutellum with a median furrow .... *sulcatus*, sp. n.
Abdomen oval, flattened above, as wide as thorax, and not at all or but slightly longer.
 Antennæ very long .... *longicornis*, Ashm.

Antennæ not especially long.
Cheeks strongly developed and, with lower face, yellow .... *ashmeadi*, sp. n.
Cheeks not especially developed, dark.
Thorax closely punctate, colour greenish.... *viridescens*, sp. n.
Thorax finely aciculate, black .... *similis*, sp. n.
Thorax faintly aciculate, greenish .... *circularis*, sp. n.
Thorax smooth, shining .... *micans*, sp. n.
Abdomen elongate, pointed, usually narrower than thorax and always considerably longer.
Yellow; abdomen with dark transverse bands .. *fasciatus*, Ashm.
Body dark, base of abdomen only light .... *basilaris*, Ashm.
Bright metallic green; coxæ light yellow ...... *coxalis*, sp. n.
Black or faintly metallic; scutellum elevated into a rounded prominence.................. *elevatus*, sp. n.
Black; scutellum for the most part in plane of scutum; scutum with impressed dots bordering inner edge of parapsidal furrow .... *vulgaris*, Ashm.
Black, without impressed dots; hind wings acutely pointed at tip .... *acutipennis*, Ashm.

TETRASTICHUS BASILARIS.

Tetrastichus basilaris, *Ashmead, Linn. Journ., Zool.* xxv. p. 186. St. Vincent.

One male, Chantilly estate, March 7, 300 feet, by shady pool in cocoa orchard.

TETRASTICHUS CUPREUS.

Tetrastichus cupreus, *Ashmead, Linn. Journ., Zool.* xxv. pp. 184–185. St. Vincent.

Sixteen male and female specimens, Mount Gay and Mirabeau estates, Grand Étang, St. George's, and Balthazar, March 7 to April 15, 300 to 1900 feet, under varying conditions.

TETRASTICHUS FASCIATUS.

Tetrastichus fasciatus, *Ashmead, Linn. Journ., Zool.* xxv. p. 187. St. Vincent.

Eleven male and female specimens, Mount Gay estate, Balthazar, March 31 to April 15, 300 to 1900 feet, under varying conditions.

TETRASTICHUS ELEVATUS, sp. n.

♀. Length 1·28 mm.; expanse 2·0 mm. Antennæ short, scape not reaching to top of head, pedicel longer than first funicle-joint; funicle-joints 1, 2, and 3 subequal in length,

flattened, a little longer than broad; club long ovate, as long as two preceding funicle-joints together; thorax short, compact; scutellum elevated; abdomen longer than head and thorax together, sides subparallel, pointed at tip; head and mesonotum nearly smooth, shining, very faintly longitudinally shagreened; abdomen smooth. Colour black; antennæ including scape dark brown, tegulæ dark brown, all femora blackish above, tibiæ and tarsi honey-yellow; wings hyaline, disc closely pubescent, veins dark brown.

Described from one female specimen, Grand Étang, March 7, 1900 feet, bank of shady stream.

TETRASTICHUS COXALIS, sp. n.

♀. Length 1·3 mm.; expanse 2·1 mm. Antennæ as with preceding species; sculpture as with preceding species, except that there are two faint punctures halfway between median suture and parapsidal groove of mesoscutum; shape and proportion of abdomen as with preceding species; central furrow of mesoscutum very faint, making the form intermediate between *Tetrastichus* and *Tetrastichodes*. General colour metallic green, head and abdomen only slightly metallic; antennæ dark brown; all legs, including front and middle coxæ, honey-yellow, hind coxæ lighter, metallic at tip; wings hyaline, wing-veins uncoloured.

One female, Mount Gay estate, April 6, 250 feet, by road in dry second-growth woods.

TETRASTICHUS MICANS, sp. n.

♀. Length 0·93 mm.; expanse 2·0 mm. Antennæ moderate; scape not reaching to top of head; first funicle-joint as long as pedicel, second and third funicle-joints subequal, not flattened; club elongate, pointed, not widened, as long as two preceding funicle-joints together; thorax and abdomen smooth, shining; central suture of mesoscutum delicate but complete; abdomen shorter than thorax, ovate; wings subhyaline, very slightly dusky. Colour black but highly glistening, very faintly metallic; antennæ, tegulæ, and all legs honey-yellow; front coxæ slightly darker near base.

One female, Balthazar, April 13, 350 feet, on shore of stream.

TETRASTICHUS ASHMEADI, sp. n.

♀. Length 1·16 mm.; expanse 2·4 mm. Antennæ long, scape reaching to top of head; funicle-joints somewhat flattened, joint 1

twice as long as pedicel, joint 2 equal to 1, 3 shorter; club a little shorter than last two funicle-joints together; abdomen about as long as thorax, short ovate; mesoscutar furrow faint; mesonotum very faintly aciculate; abdomen smooth; wings perfectly hyaline, veins light brown. General colour black; antennæ dark brown; face, especially below, tegulæ, postscutellum, base of abdomen above, and all legs including coxæ, honey-yellow.

Six females, Balthazar, March 31 to April 15, all but one at 1900 feet, on foliage on ground; remaining one at 300 feet on shady bank of stream.

TETRASTICHUS SIMILIS, sp. n.

♀. Length 1·35 mm.; expanse 2·9 mm. Antennæ moderate, scape reaching above top of head; funicle-joints subequal in length and width, not flattened, each somewhat longer than pedicel; club not widened, as long as two preceding funicle-joints together; head and mesonotum faintly shagreened; abdomen short, rotund, shorter than thorax; wings very faintly dusky, veins brown. General colour black, faintly glistening; flagellum of antennæ dark brown, pedicel and scape honey-yellow, tegulæ dark brown; all legs honey-yellow, except coxæ which are black.

One female, Grand Étang, 1900 feet, March 31, on foliage on ground.

TETRASTICHUS LONGICORNIS.

Tetrastichus longicornis, *Ashmead, Linn. Journ., Zool.* xxv. p. 185. St. Vincent.

Three females, Mirabeau estate, April 5, 400 feet, about cocoa orchard; Chantilly estate, April 6, 400 feet, weeds about nutmeg orchard; Balthazar, April 13, 350 feet, second growth on shore of stream.

TETRASTICHUS VULGARIS.

Tetrastichus vulgaris, *Ashmead, Linn. Journ., Zool.* xxv. p. 185. St. Vincent.

Five females, Mirabeau estate, April 5, 400 feet, cocoa orchard; Chantilly estate, April 6, 400 feet, nutmeg orchard; Balthazar, April 3 and 7, 250 feet, open weedy places; Mount Gay estate, April 6, 250 feet, in house on window.

TETRASTICHUS CUPROIDEUS, sp. n.

♂. Length 1·98 mm.; expanse 3·5 mm. Antennæ nearly as

long as entire body; head finely shagreened, with a row of large punctures at fore border of eyes; pronotum transversely shagreened, with a row of large impressions at posterior border; mesoscutum longitudinally shagreened, without marginal impressions as with *T. cupreus*; mesoscutellum also longitudinally shagreened; metanotum closely, rather finely punctured, with pronounced longitudinal median carina; abdomen shining, with very faint shagreening; pro-, meso-, and metapleura closely and rather finely punctate; hind coxæ also punctate on outer surface and with two slight longitudinal carinæ. Colour bright metallic green; abdomen darker, yellowish above and below at base; all legs honey-yellow, except coxæ and base of hind femora which are dark and more or less metallic; scape of antennæ honey-yellow, with a black or brown stripe below; flagellum brownish with dark hairs; wings hyaline, veins light brown.

One male, Balthazar, April 15, 250 feet, shady place near stream.

Tetrastichus acutipennis.

Tetrastichus acutipennis, *Ashmead*, *Linn. Journ.*, *Zool.* xxv. p. 186. St. Vincent.

One female, Mount Gay estate, April 3, 250 feet.

Tetrastichus viridescens, sp. n.

♀. Length 1·58 mm.; expanse 2·9 mm. Body stout, compact; pronotum and metanotum scarcely visible; metascutellum nearly smooth, very short, with faint median carina; abdomen rather coarsely shagreened; pleural sclerites delicately punctured; hind coxæ punctured above but not carinate; antennæ short, scarcely reaching to top of head; flagellum scarcely longer than face; facial depression large; head and thorax very closely and rather finely punctate; mesoscutum with marginal row of large, close-set punctures. Colour dark with metallic green reflections, on abdomen blue-green; pedicel, underside of scape, tegulæ, all tibiæ and tarsi honey-yellow; all coxæ metallic, all femora black or slightly metallic; wings hyaline, wing-veins very light.

One female, Balthazar, April 13, 350 feet, second growth on shore of stream.

Tetrastichus sulcatus, sp. n.

♀. Length 1·7 mm.; expanse 3·2 mm. Body stout; abdomen a trifle longer than thorax, ovate, pointed, circular on cross

section; segments 2 to 4 subequal in length, 5 a little longer; antennæ moderately long; funicle-joints subequal in length, each a little wider than long; club longer than two preceding funicle-joints together. Head and disc of mesoscutum closely and faintly aciculate-punctate, parapsides reticulate; mesoscutar furrow wanting on cephalic half of the sclerite; scutellum striate, with a central longitudinal furrow in addition to the two lateral furrows; pleura and outer side of coxæ closely and faintly punctate; abdomen finely reticulate. General colour dark metallic blue; abdomen blue at base, brownish towards tip; all trochanters, tibiæ and tarsi, as well as scape and pedicel, pallid; proximal half or two-thirds of all femora dark brown; funicle and club of antennæ dark brown; wings hyaline, veins light brown.

One female, Balthazar, March 31, 1900 feet; on foliage near the ground, damp spot near water.

Tetrastichus circularis, sp. n.

♀. Length 1·0 mm.; expanse 2·1 mm. Body stout, compact; abdomen flattened, almost perfectly circular from above, slightly wider than thorax but not so long; segment 2 longest, 3 and 4 subequal. Head and mesonotum faintly aciculate-punctate; median furrow of mesoscutum faint; pleura and hind coxæ reticulate, reticulations becoming lengthened on the mesopleura; funicle-joints of antennæ somewhat flattened, hairy, subequal in length and breadth, each one-half longer than broad; club ovate, flattened, wider than funicle and nearly as long as two preceding funicle-joints. General colour black, shining, with faint metallic reflections; antennæ including scape black; tibiæ and tips of femora honey-yellow; tarsi brown, gradually becoming more intense from joint 1 to joint 4; trochanters light; femora except tips dark brown.

One female, Balthazar, April 6, 250 feet, dry second-growth woods, on foliage.

Tetrastichus (?) fuscipennis, sp. n.

♂. Length 1·2 mm.; expanse 2·2 mm. Body rather slender; abdomen ovate, flattened from above, subpetiolate; segment 2 longest, 3, 4, and 5 subequal. Head and thorax nearly smooth, shining, very faintly reticulate; metanotum finely rugose, with divided central carina, lateral spaces divided obliquely by slight carinæ; abdomen smooth and shining; antennæ hairy, sub-

clavate; scape nearly as hairy as flagellum; pedicel long, slender, three times as long as first funicle-joint; funicle-joints subequal in length, increasing slightly in breadth; club ovate, wider than terminal funicle-joint and nearly as long as two preceding funicle-joints together; thorax with sparse stiff black bristles. General colour black, shining; thorax above dark brown; pronotum darkest, metanotum lightest; petiole light brown; all legs including coxæ pallid, femora and tibiæ a little darker in the middle; scape and pedicel pallid; funicle-joints darker, club lighter; fore wings dusky, especially towards centre.

One male, Balthazar, March 5, 250 feet. Probably generically separated from *Tetrastichus*, but in the absence of the female it is thought best not to erect a new genus.

Gyrolasia, *Foerster.*

Gyrolasia ciliata.

Gyrolasia ciliata, *Ashmead, Linn. Journ., Zool.* xxv. p. 180. St. Vincent.

Three females, Balthazar, March 31, April 15, two at 300 feet and one at 1900 feet.

Gyrolasia metallica.

Gyrolasia metallica, *Ashmead, Linn. Journ., Zool.* xxv. p. 181. St. Vincent.

One female, Mirabeau estate, April 5, 400 feet, from herbage about cocoa orchard.

Gyrolasia bicolor.

Gyrolasia bicolor, *Ashmead, Linn. Journ., Zool.* xxv. p. 180. St. Vincent.

Numerous male and female specimens, Chantilly estate, and Balthazar, March and April, under varying conditions.

Gyrolasia flava, sp. n.

♀. Length 9·5 mm.; expanse 1·7 mm. Scape slender, pedicel very short; funicle-joint 1 three times as long as pedicel, joints 2 and 3 subequal to 1; club attenuate; thorax faintly shagreened; abdomen long, pointed, as long as head and thorax together. General colour bright yellow; funicle-joints 1, 3, and club black; the six principal piliferous spots also black (four on mesoscutum and two on scutellum); abdomen dark yellow, segments with brown borders, pygidium black; all legs honey-yellow; wing-veins dark brown; eyes dark red.

One female, Balthazar, June 11, 250 feet, flying at sunset after heavy rain.

TETRASTICHODES, *Ashmead.*

TETRASTICHODES COMPACTUS, sp. n.

♀. Length 1·9 mm.; expanse 2·8 mm. Body stout, compact; abdomen full, round, large, as broad as thorax, long ovate, as long as head and thorax together; antennæ short, scape slender, pedicel shorter than first funicle-joint; funicle-joint 2 shorter than 1, 3 equal to 2; club ovate, widest at base, as long as two preceding funicle-joints together. Facial depression triangular, sides broadly rounded, its upper margin immediately in front of middle ocellus, and nearer to this than ocellus is to occipital margin; head closely and finely punctate, without larger punctures; pronotum, except for smooth hind border, all of mesonotum, pleura, and hind coxæ closely and finely punctate; abdomen strongly shagreened; punctation of mesoscutellum sublongitudinal, converging slightly towards centre, and forming a spurious median longitudinal groove, apparent in some lights and not perceptible in others; metanotum with close round punctures, the disc forming a triangle by means of two carinæ converging towards apex, divided by a well-marked central longitudinal carina. Colour metallic green; tegulæ black; scape and pedicel of antennæ, and all tibiæ and tarsi honey-yellow; funicle and club dark brown; all femora black, somewhat metallic on middle, honey-yellow at each extremity; coxæ metallic, trochanters honey-yellow; wings hyaline, veins light brown.

♂. Length 1·5 mm.; expanse 2·5 mm. Antennæ long; funicle-joints subequal in length, each nearly twice as long as pedicel; coloration and punctation as with female, except that disc of metanotum is more rugoso-punctate, and the central carina almost immediately divides.

Described from seven females and two males, Mirabeau and Mount Gay estates, and Balthazar, March 31 to April 7, under varying conditions.

TETRASTICHODES COXALIS, sp. n.

♀. Length 1·28 mm.; expanse 2·2 mm. Stout-bodied; abdomen full, rounded, very slightly flattened dorso-ventrally, nearly as long as head and thorax together; antennæ short, flagellum flattened from side, pedicel nearly as long as first funicle-joint;

first and second funicle-joints subequal in length and width, third shorter and wider; club ovate, about as long as two preceding funicle-joints; head and mesonotum closely and finely shagreened; the spurious central carina of scutellum lacking; metanotum with a short, distinct, median longitudinal carina, the spaces on either side pentagonal in shape; all pleura and hind coxæ closely and finely punctate, except for a smooth strip at hind border of mesepimeron. Colour black, shining, very slightly metallic; antennal scape at tip, with all of pedicel, all tibiæ, hind coxæ, all trochanters, and hinder portion of metanotum honey-yellow; wings hyaline, veins dark brown.

One female, Balthazar, March 5, 250 feet, at sunset in cocoa orchard.

Tetrastichodes cupreus.

Tetrastichodes cupreus, *Ashmead, Linn. Journ., Zool.* xxv. p. 182, ♂ ♀. St. Vincent.

Two males, Mirabeau estate, March 25, 500 feet, on herbage near stream.

Tetrastichodes femoratus.

Tetrastichodes femoratus, *Ashmead, Linn. Journ., Zool.* xxv. p. 183, ♂ ♀. St. Vincent.

Two females, Mount Gay estate, 250 feet, April 3 and 6, on foliage in dry second-growth woods.

Tetrastichodes flavipes, sp. n.

♀. Length 1·1 mm.; expanse 2·1 mm. Occiput, pronotum, and sides of mesoscutum finely punctate, mesoscutum striate-punctate in middle; scutellum irregularly striate; vertex nearly smooth, face with fine close round punctures; metanotal carina distinct, complete, lateral spaces striate; pleura and outer side of coxæ punctate; abdomen closely and uniformly reticulate punctate, segments 2, 3, and 5 subequal in length, 4 a little longer; antennæ with the three oval funicle-joints subequal in length, each twice as long as wide; club long oval, as long as two preceding funicle-joints together, its basal joint unusually well separated. General colour black with slight greenish metallic lustre; all legs, including tips of coxæ, and all of antennæ honey-yellow; wings hyaline.

One female, St. George's, March 2, 250 feet.

Tetrastichodes nigriscapus, sp. n.

♀. Length 1·2 mm.; expanse 2·4 mm. Sculpturing in

general like preceding species but somewhat finer. Abdomen broad oval, nearly circular, flattened; relative length of segments as with preceding species; funicle-joints of antennæ flattened, subequal in length and breadth, subrectangular, hairy. General colour dark metallic green; all femora and tibiæ honey-yellow, except hind femora which are concolorous with body, light at each end; antennæ including scape black; wings hyaline, veins dark brown.

One female, Balthazar, April 5, 250 feet, open place, on bush at sunset.

CERATONEURA, *Ashmead.*

CERATONEURA PETIOLATA.

Ceratoneura petiolata, *Ashmead, Linn. Journ., Zool.* xxv. p. 179. St. Vincent.

Two females, Balthazar and Mount Gay estate, April 6 and 7, 250 feet, on herbage near stream and dry second-growth woods.

PENTASTICHUS, *Ashmead.*

PENTASTICHUS LONGIOR, sp. n.

♀. Length 1·16 mm.; expanse 1·8 mm. Body rather slender; abdomen pointed, as long as head and thorax together; head and mesonotum shining, extremely delicately shagreened; metanotum without median carina. Colour black, with slight metallic reflections; antennæ dark honey-yellow, pedicel darker; pubescence on club whitish; tegulæ dark brown; all legs light yellowish; femora black, light at each end; wings hyaline, veins light brown.

One female, Balthazar, April 7, 250 feet, herbage near stream.

PENTASTICHUS FLAVUS, sp. n.

♀. Length 0·81 mm.; expanse 1·86 mm. Body stout, compact, flattened from above; abdomen broad oval, nearly circular, as broad as thorax and somewhat shorter. Antennæ short, rather slender, not gradually but abruptly clavate. Colour light, almost translucent yellow, like that of *Aphelinus*; eyes and ocelli dark red; antennæ a little darker towards tip; wing-veins yellowish.

One female, Balthazar, June 11, 250 feet, flying at sunset after heavy rain.

Subfamily Trichograminæ.

Paracentrobia, gen. nov.

Antennæ 6-jointed, funicle 1-jointed, club 3-jointed. Meso-postscutellum plainly discernible, with a triangular projection from its extremity somewhat as with *Perissopterus* (subfamily *Aphelininæ*). Fore wings broad, with a short but close-set marginal cilia beginning on apical fore border and extending around on hind border nearly to base; discal cilia very numerous and very close-set, but arranged in regular rows. Submarginal and marginal veins short, postmarginal lacking; stigmal curving abruptly down into the disc of wing at half wing-length and somewhat knobbed at tip.

Paracentrobia punctata, sp. n.

♀. Length 1·0 mm.; expanse 2·1 mm. Scape stout, somewhat swollen; pedicel subtriangular, two and a half times as long as thick, the sole funicle-joint cup-shaped, less than half as long as pedicel; joint 1 of club as broad as long, longer and broader than funicle-joint and also somewhat cup-shaped; joint 2 of club cylindrical, as long and as wide as joint 1, joint 3 attenuated, pointed, and as long as 2. Abdomen long, slender, pointed, longer than thorax and head together. General colour orange-yellow; eyes red; antennæ and legs pallid, femora somewhat dusky in middle; each segment of abdomen with a black dot on outer margin; wing-veins dark brown; thorax not punctured.

One female, Mount Gay estate, April 1, 250 feet, on window in house.

Notes on the Minute Structure of the Nervous System of the Mollusca.

By J. Gilchrist, M.A., B.Sc., Ph.D., Marine Biologist to the Government of the Colony of the Cape of Good Hope. (Communicated by B. B. Woodward, F.L.S.)

[Read 21st January, 1897.]

(Plate 12.)

The following additions to our knowledge of the nervous system of the Mollusca is a first contribution to a more extensive and comparative review of the subject. It is an account of some definite results obtained by the use of methylene-blue and more especially of my experience with modern methods, which I deem it desirable to place on record, as other investigators have experienced difficulty in the attempt to apply them to the study of histology of the Molluscan nervous system. In the prosecution of the work I have been especially indebted to Dr. Bethe, whose intimate acquaintance with methylene-blue method and readiness to impart information have been of the greatest assistance.

Method.

Though a good deal can be done with ordinary methods towards demonstrating the finer branches of nerve-cells and the course of nerve-fibres in Mollusca, it is necessary to use either the method of Golgi or the methylene-blue method to obtain good results. Of the two methods, that of Golgi seemed to be the most promising; but while Retzius (6) and Samassa (8) have used it successfully on the Pulmonata, they have found it inapplicable to marine Mollusca.

Joubin (7) has obtained a coloration of the nervous system of some cephalopods by injection of methylene-blue, but apparently without noting if this was a differential stain for cells.

Having observed, by former trials with methylene-blue that there was evidently a differential staining of the fibres of the nerves, it seemed to me probable that means could be found of further applying this beautiful method to the Mollusca, both terrestrial and marine. Accordingly, after a few unsuccessful attempts with the Golgi method, I returned to the methylene-blue, and, after many failures, at last obtained some satisfactory results.

I need not mention the various difficulties met with, or how

they were overcome; but shall merely describe the method which I ultimately found workable.

An important factor seems to be the kind of blue used, as, out of the several sorts tried, one (the Höchst) gave much better results than the others.

A nearly saturated solution of the blue was made in distilled water (not salt solution), and about 2 cub. cent. of it injected into the living animal. It was found that this can be done best through the muscular foot, as the puncture is soon closed and escape of the injecting material prevented. The animal thus injected was put back into sea-water and left for an hour or two; and it was found advisable to operate on several animals at once, if material were abundant. The nervous system could then be laid bare, or dissected out and laid on a slide, just enough water being added to keep the preparation from drying up. At times no coloration was at first observed, but soon (by oxidation) the blue appeared. This generally happened in a few minutes; and the process could be easily watched under the microscope and stopped at any stage. It was found that, as a rule, the outside of the ganglia became coloured only before or when the colour had spread from the nerve into the ganglion-cells. This outside had therefore to be removed, as fortunately was possible by embedding and cutting with a microtome in the usual way, thanks to Dr. Bethe's method of fixing the stain with ammonium molybdate; but there was thus introduced another possible difficulty, in addition to that caused by the erratic selection of the elements by the blue, as fibres or cell-processes once cut were very difficult to determine in the next section. Both difficulties, however, were overcome by making abundant preparations, and by cutting thick sections (·5 millim.) which to a certainty would include complete cells. The cut parts, moreover, could be readily recognized by their abrupt endings.

The central nervous system having been thus got at, it remained to find a method for demonstrating the peripheral nervous system, and the sensory cells of the epidermis and the higher sense-organs. Since the essential point was to get the blue in direct contact with the elements to be stained, it appeared from the afore-mentioned trials that this might best be assured by injecting through the blood-system. Accordingly a large quantity of the solution was forcibly injected until the blue showed through the epidermis. A piece of the tissue thus coloured, treated as

before (*i. e.* cut out, exposed to the air, and cut into sections) showed sensory cells most satisfactorily. The sensory cells in the osphradial epithelium could also be thus differentiated; but a special difficulty was met with in the tentacles, owing to their immediate and prolonged contraction on the slightest irritation, by which the reagent was driven completely out of them. Attempts were made to force the blue into the tentacles by various devices; but the difficulty was only finally got over by injecting the animal with cocain (5 per cent. in sea-water) and a few minutes afterwards injecting the blue, which then readily penetrated the relaxed tentacles. Under this treatment, however, the animal (*Aplysia*) died much sooner than when the blue was alone injected; and it is well known that the colouring-matter employed rapidly diffuses on the death of the tissues. Only a few sensory cells were seen in sections thus prepared; and as no more animals were forthcoming the experiment was not repeated.

Material.

The animal with which the best results were obtained, and which was easiest to manipulate on account of its size and absence of a hard shell, was *Aplysia.* The nervous system of *Aplysia* is, moreover, not so concentrated as that of the Nudibranchs, and the cells and fibres are fairly large in contrast to those of the Prosobranchs. Moreover, the stain did not seem suitable for other Opisthobranchs, as in the animal tried (*Doris*) it was found to become, as it were, scattered, the fibres having apparently broken up into segments. The attempt to stain small transparent Nudibranchs by leaving them in a weak solution was unsuccessful. With the Prosobranchs only a partial success was obtained in the case of *Patella.* No success at all was met with in the treatment of Lamellibranchs; but I have no doubt that the method could be applied to all Mollusca if time and trouble were taken to determine the treatment suitable to individual cases.

Central Nervous System.

Fig. 1 diagrammatically delineates a section through the nervous system of *Limnæa*, and will give a general idea of the relation of its parts, and the relative size and distribution of the ganglionic cells and nerve-fibres. The arrangement is typically that met with in the Pulmonata and Opisthobranchiata, the various

forms having been observed to differ only in the degree of concentration of the ganglia, a fact well worthy of further investigation. Thus, in the very interesting œsophageal ring of *Pleurobranchus* the ganglia are so concentrated as to form a sort of brain; and they present several other striking peculiarities. The object which I had in view with this animal was the determination of the minute structure of these ganglia, which could be to a certain extent arrived at by ordinary methods. Aniline-black (not the Continental, which is different from the English) was found a very suitable stain for the purpose; but all were quite inadequate to bring out the finer details, such as are shown in the accompanying figures.

The buccal ganglia of *Aplysia* can be dissected out with ease, and as they took the stain readily they were suitable objects for preliminary study. Fig. 2 delineates the general arrangement of the cells and fibres in these ganglia. It appears from the preparations that the cells consist of (1) typical motor-cells (a, a') each with a long axis-process leading away into the nerve and other processes which break up into fine branches in the ganglia; (2) of cells (b, b') the smaller processes of which break up in one ganglion while the main process passes over into another, and probably there breaks up into small branches, though this latter point was not observed.

A great many of the fibres pass from the nerves over the ganglion, and some of these (c) were observed to give off fine branches. The two fibres e and e', the detailed relationships of which I have not determined, appeared unexpectedly in one preparation; in another, at d and d', exceptionally thick fibres appeared, and it was found that they came directly from the cerebral ganglia and joined the nerve which runs to the mouth-region. Though these were not actually traced to the sensory organ which has been shown to exist there, they probably innervate it. As all the other sense-organs (including the osphradium, as demonstrated by Pelseneer for one group) have been shown to be in direct connexion with the cerebral ganglia, this is of interest. Not only is the exceptional thickness of the fibres, as compared with those in the other nerves, noteworthy, but also their small number—only two having been detected in each nerve examined.

The curious fact that corresponding cells and fibres in the opposite ganglia become coloured at the same time, which has been noted by other observers in other groups, was well illustrated

in these preparations. Thus the elements a and a' were differentiated in one preparation, b and b' in another, and so on.

Of all the ganglia examined, the best results were obtained with the *pleural*. In them the finer branchings of the cells were very apparent; and figs. 3, 4, 5, and 6 show the kinds of cells met with—fig. 3 a and fig. 4 being of the type already met with in the buccal ganglia, with branching processes and axis-fibre running to a nerve. Fig. 3 b is apparently a "co-ordinating" cell, with simple arborescence. Various fibres entering the pleural ganglia were seen to break up and end within them in fine branches; and the same was observed in the cerebral and pedal ganglia, which require further investigation. A series of fibres running across the two pedal ganglia and giving off fine branches, a plexus of nervous elements on the nerve near the ganglia, and various isolated facts of similar nature were noted, but not fully worked out.

The two visceral and the single abdominal ganglia present in some Gastropods are in *Aplysia* represented by two (*cf.* fig. 1) which might represent either the right visceral and abdominal or the two viscerals, the abdominal having disappeared. One of the preparations of this complex, however, showed what appeared to be a group of small deeply-stained cells just within one of the ganglia (fig. 7, a); and it appears to me possible that this may represent a degenerated abdominal ganglion.

The other cells of these ganglia (fig. 7, b) were of the type already met with. Fibres were seen entering and breaking up within the ganglia (fig. 7, c), but their connexions were not traced; and a number of fibres (fig. 7, d) were seen to pass over the ganglia.

Peripheral Nervous System.

With this some satisfactory results were in *Aplysia* obtained by the methylene-blue method.

Fig. 8 represents a section of a piece of tissue cut out of the side of the body, and shows the presence of long sensory cells (c) with a slight expansion at a varying distance from the epithelium, and a nucleus (n) which stains deeper than the cell-body. Their mode of termination in the epithelium (fig. 8, c') was observed in thin sections. A number of deeply stained fibres were observed just beneath the epithelium (pl), with occasionally a related nucleated cell (n'). These structures may represent a hypodermal nerve-plexus similar to that demonstrated by

Dr. Bethe in other groups; and surface sections would doubtless throw light on this point.

The osphradium of *Aplysia* was found to be a simple sensory organ peculiarly suited to the method of investigation adopted. It is a small circular patch of epithelium surrounded by a ring of dark pigment situated at the anterior end of the ctenidium. Immediately under this epithelium is a ganglion, which is little more than a collection of cells on the nerve coming from the right visceral ganglion (fig. 9, *g*).

Various attempts have been made to discover the connexion between the osphradial epithelium and the underlying ganglion in the Mollusca, and peculiar small cells have been described in the former. A successful methylene-blue preparation demonstrated without doubt the existence of intra-epithelial structures (fig. 9, *a*) and showed their true nature, viz., that they are the peripheral endings of sensory cells, the nucleated bodies of which lie at a greater or less depth under the epithelium, and the lower offshoots of which penetrate the ganglion. Certain of the basal fibres of these cells were observed (fig. 9, *b*) to pass out at the side of the ganglion, sometimes in bundles, sometimes singly. The corresponding peripheral sensory processes of their parent cells were found within the neighbouring epithelium, beyond the region of the osphradial pit proper; and they present a structural condition intermediate between the short cells of the epithelium over the ganglion and the longer sensory cells of the general epithelium afore described. Perhaps these are to be regarded as indicative of a former condition, in which the osphradial epithelium was of much greater extent than now *.

The sensory cells seemed to break up into fine branches within the ganglion (fig. 9, *c*), and the majority of the cells of the latter are similar to the elements already described for other ganglia. The outer extremities of the sensory cells, as will be seen from fig. 10, project a considerable distance beyond the epithelium, and present a bent and swollen condition, probably the result of treatment in staining and fixation, suggestive of Flemming's "pinselförmige Zellen." In one case the nucleated body of a sensory cell appeared to lie within the epithelium; but this was doubtful, and may have been due to the fact that the ordinary

* I have elsewhere given reasons for believing that we have here to do with a degenerate organ. *Cf.* Jenaische Zeitschr. Bd. xxviii. p. 408.

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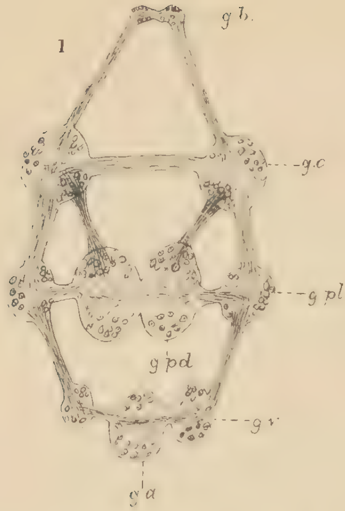

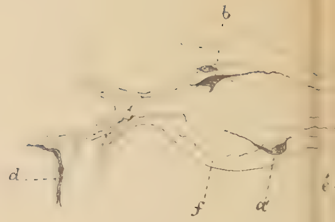

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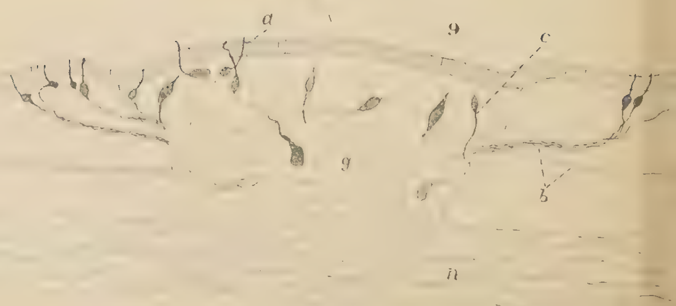

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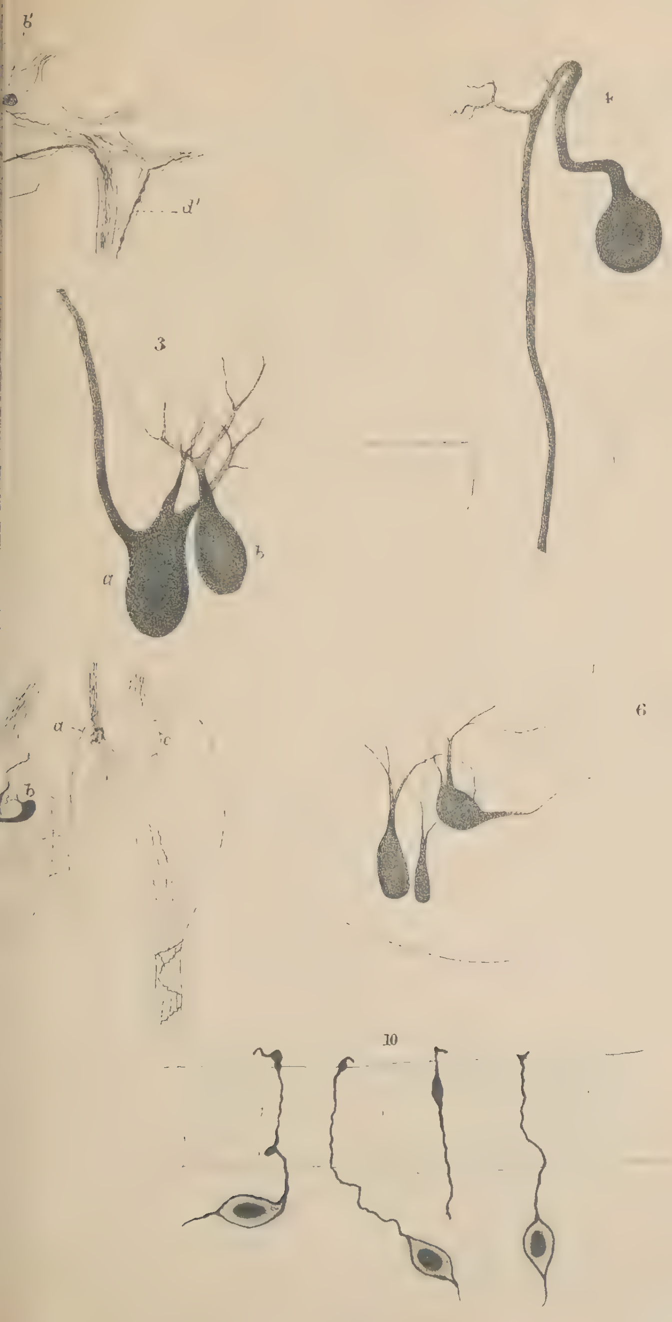

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OLLUSCA.

epithelial cell sometimes takes up the blue coloration in a marked manner, while its fellows remain unstained.

It remains but to state as a result obtained with the rhinophore, that there is an arrangement of ganglionic cells somewhat similar to that of the osphradium. Although none of the preparations (for reasons already stated) showed many details, a few sensory cells were observed.

I hope thus to have shown that the methylene-blue method can be satisfactorily applied to the study of the nervous system of at least some of the Mollusca.

As these notes are merely a first report of the results of a particular application of a method, it has not been deemed necessary to discuss them at any length, or to give a detailed account of the work of others in the same field. I append references, however, to some of the more important works which contain full bibliographies beyond those alluded to in the text.

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EXPLANATION OF PLATE 12.

Fig. 1. *Limnæa.* Diagram showing relative position and size of cells and fibres in the ganglia. *g.a.*, Abdominal ganglion; *g.b.*, buccal ganglion; *g.c.*, cerebral ganglion; *g.pd.*, pedal ganglion; *g.pl.*, pleural ganglion; *g.v.*, visceral ganglion.

Fig. 2. *Aplysia.* Section across buccal ganglia, built up from several methylene-blue preparations.

Figs. 3, 4, 5, & 6. *Aplysia.* Different types of uni-, bi-, and multipolar cells from the pleural ganglia. In figs. 3 *a* and 4 the axis process was traced into a nerve.

Fig. 7. *Aplysia.* Section across visceral ganglia, showing—*a*, group of small cells; *b*, ordinary cells of ganglia; *c*, branching fibre from nerve; *d*, nerve passing over ganglion.

Fig. 8. *Aplysia.* Section of general epidermis showing—*c* and *c'*, sensory cells; *pl.*, subepithelial nerve-plexus.

Fig. 9. *Aplysia.* Section of osphradium. *n*, Nerve; *g*, ganglion; *a* & *b*, sensory cells and their processes, and at *c* one of the latter branching.

Fig. 10. *Aplysia.* Osphradial epithelium, with group of sensory cells showing mode of termination.

A Contribution to the History of New Zealand Echinoderms. By H. Farquhar. (Communicated by T. W. Kirk, F.L.S., Government Biologist, Department of Agriculture, New Zealand.)

[Read 4th February, 1897.]

(Plates 13 & 14.)

The material from which the following notes have been drawn up consists principally of a collection of Echinoderms made at Nelson by Mr. E. Lukins, and a small but exceedingly interesting collection brought from Raoul or Sunday Island by Mr. A. A. S. Danby, who was a passenger in the Government steamer 'Hinemoa' on her last annual trip to the Kermadecs. My thanks are due to these two gentlemen for their kindness in placing these valuable collections in my hands.

I give an account in this place of the collection from the Kermadec Islands, although the marine fauna of these islands belongs rather to the tropical division of the Australian Region than to New Zealand. The islands can, however, be most conveniently worked from New Zealand, as they now form part of this Colony, having been annexed in 1887.

I take this opportunity of correcting errors in my previous paper on New Zealand Echinoderms (Trans. N. Z. Inst. vol. xxvii. p. 194). Throughout that paper I have inadvertently used the wrong descriptive terms for the pedicellariæ: "forcipiform" should be "forficiform," and *vice versa*. Corrections of mistakes in nomenclature will be found noted where necessary.

I desire to acknowledge my great indebtedness to Mr. Sladen's admirable monograph of the Asteroidea ('Challenger' Report, vol. xxx.). He has there thrown a flood of light on this class, and reduced to order a mass of material which was largely in a state of chaos. The late Mr. Lyman's monograph of the Ophiuroidea ('Challenger' Report, vol. v.) has also been of much assistance, enabling me to identify species, and place them in their proper systematic position. Every worker at the Echinoderms must be thankful for these two important works.

The identification of specimens is often rendered a matter of considerable difficulty by the limited number of works of reference available in New Zealand; and students of nature feel the disadvantage of being so far away from all the great scientific libraries.

I had hoped to have published a complete list of New Zealand Echinoderms, with synonymy, references, and distribution of the species, which I have compiled; but one or two doubtful points in the synonymy have occasioned delay in publication.

ECHINOIDEA.

ECHINOCARDIUM AUSTRALE, *Gray*.

In a former paper ("Notes on N. Z. Echinoderms," Trans. N. Z. Inst. vol. xxvii.) I stated that the specimens of *Echinocardium* collected by me in the Wellington Harbour differed markedly from the Australian form *E. australe*. I have since received a fine example of *E. australe*, and a series of intermediate specimens, collected by Mr. Lukins at Nelson. The form which is abundant in Wellington Harbour is therefore merely a local variety of the common Pacific species *E. australe*. This species is remarkable for its range in depth, extending from a few feet to 2675 fathoms, at which great depth it was taken near Japan by the naturalists of the 'Challenger' Expedition. Its geographical range is also great, including the whole of the Southern Ocean, and extending northwards to Japan.

EVECHINUS CHLOROTICUS, *Valenciennes.* (Plate **14**. fig. 9.)

Professor Jeffrey Bell, who has exceptional opportunities of studying the great variations of many Echinoderms, will not be surprised to learn that the two small specimens of *Evechinus* in the British Museum, for which he erected his new species *E. rarituberculatus* (Ann. & Mag. Nat. Hist. (5) xx. p. 403), are but young individuals of the common New Zealand form *E. chloroticus*. I have carefully examined a number of young specimens, and I find that they vary a good deal, some of them agreeing well with Prof. Bell's figures. The description, however, appears to be somewhat mixed, ambulacral having been substituted for adambulacral, and *vice versa*. The largest example of this species that I have seen is in the Colonial Museum: the height of the test is 93 mm., the diameter 145 mm., and the longest spine 40 mm.

TRIPNEUSTES VARIEGATUS, *Klein.*

Two very fine examples of this exceedingly variable and widely distributed species were collected by Mr. Danby at Raoul Island. They differ remarkably from the specimens described by Agassiz in his great work, 'The Revision of the Echini;' but correspond more nearly with those from Mauritius described by M. de Loriol (Mémoires Soc. Phys. de Genève, xxviii. No. 8, p. 25, 1883). The general form of the Kermadec specimens is much depressed, roundly subpentagonal seen from above, actinal surface flat. The poriferous zones are somewhat sunken on the actinal surface; but above the ambitus the whole ambulacral areas are swollen. The actinal cuts are narrow, but deep and well defined. The dimensions are about the same in both specimens:—Height 57 mm.; diameter 114 mm.; diameter of abactinal system 18 mm.; diameter of actinal system 27·3 mm.; width of poriferous zone at the ambitus 9 mm.; length of longest spine 20 mm.

ECHINOMETRA LUCUNTER, *Leske.*

A specimen of this species from the Kermadec Islands has been presented to the Colonial Museum, Wellington, by Mr. H. Travers. Both the Echinoids which have been found at the Kermadecs belong to the order of regular Echini (Desmosticha), and both are very variable and widely ranging forms. Their areas of distribution are almost the same, extending from the

Red Sea down the east coast of Africa to India, and through the Eastern Archipelago and the Polynesian Islands to the Kermadecs. The present species (*E. lucunter*) extends to Japan and down the north-eastern coast of Australia to Lord Howe Island. When a thorough search is made at the Kermadecs, no doubt a number of other Polynesian species will be found there.

STRONGYLOCENTROTUS TUBERCULATUS, *Lamarck*.

This species was recorded from New Zealand by Agassiz in his 'Revision of the Echini,' pp. 165, 451. I am able to verify its occurrence in our seas, as there is a fine New Zealand specimen in the Colonial Museum, Wellington.

STRONGYLOCENTROTUS EURYTHROGRAMMUS, *Valenciennes*.

Agassiz, in the work above quoted, does not give New Zealand in the list of localities where this species has been found (pp. 163 & 442); but on p. 238 it occurs in a list of S. Atlantic Echini as a New Zealand species. I have not been able to find any authority for that statement, although it has been twice recorded from the South Pacific. I am able, however, to state that it is certainly a member of the New Zealand fauna, for there are two specimens in the Colonial Museum, which were found near Wellington by Mr. T. W. Kirk.

CENTROSTEPHANUS RODGERSII, *Agassiz*.

I am able to add this species to our fauna, for there was a New Zealand specimen in the Colonial Museum. Unfortunately the damp had affected it so much that it fell to pieces when an assistant attempted to remove it from the case.

OPHIUROIDEA.

OPHIOPEZA DANBYI, sp. n. (Plate **14.** figs. 7, 8.)

The disc is flat, subpentagonal, and covered with a fine close granulation. It is about 20 mm. in diameter. The length of the arms is about five and a half times the diameter of the disc. They are rather stout, and taper towards the extremity. There are about twelve mouth-papillæ to each angle; they are small, blunt, rounded, subequal, and closely set. The mouth-shields are rather large, roundly elliptical. The side mouth-shields are small, inconspicuous, and irregular in shape. The under

arm-plates are squarish, with rounded angles. The upper arm-plates are oval, broader than long. The side arm-plates bear four blunt, stout, somewhat flattened, subequal arm-spines, about 3 mm. in length. There are two small leaf-like tentacle-scales to each pore. The colour of the disc is greyish brown, and the rays are blackish grey above, slightly variegated with yellowish and lighter grey beneath.

This form may be readily distinguished from all the other species of the genus *Ophiopeza* by the small number of arm-spines (4) and their large size. One specimen of this species was found by Mr. Danby at Raoul Island.

The diagnosis of the genus *Ophiopeza*, as defined by Lyman ('Challenger' Report, vol. v. p. 30), will have to be slightly modified to admit this species.

Ophiopeza cylindrica, *Hutton*. (Plate **14.** figs. 4, 5.)

The disc is subpentagonal, with slight indentations at the bases of the arms. The arms are short, about three or three and a half times the diameter of the disc; they taper evenly to a fine extremity. There are six or seven mouth-papillæ on each side of the mouth-angle, the outermost one is small and narrow, the next large and broad; then follow three or four small, rounded, bluntly-pointed ones, and the pair at the apex are somewhat longer and sometimes broader than these. The mouth-shields are rather large and shield-shaped. The side mouth-shields are small and narrow. The under arm-plates are slightly longer than broad, convex without. The upper arm-plates are oblong, with rounded angles broader than long. The side arm-plates bear six or seven short, blunt, compressed arm-spines. There are two leaf-like tentacle-scales to each pore, the outer one smaller than the other. The colour of this species varies very much; some specimens are dark grey, the disc slightly variegated or spotted, and the rays banded with white or pale grey; others are yellowish white variegated with grey, or the rays banded and the disc variegated with bright reddish brown.

Pectinura maculata, *Verrill*.

This species seems to be distributed all round the New Zealand coasts. Mr. H. B. Kirk informs me that it is abundant at Stewart Island, on the sandy bottoms of the inlets and sheltered coves. Mr. Lukins has sent me a specimen which he found at

D'Urville Island; and Mr. Haylock has collected half a dozen specimens under stones at low water near Wellington. The colour in life is chocolate or bright reddish brown above, with a ten-rayed blackish star on the disc, and the upper surface of the rays is sometimes blackish, and the actinal surface pale reddish or purplish.

AMPHIURA PUSILLA, sp. n. (Plate **14.** figs. 1, 2, 3.)

The disc is rather tumid, circular, with a wavy margin; it is covered with rounded, imbricating, somewhat irregular scales, which decrease much in size near the margin of the disc. The scaling on the actinal surface is much finer and more regular than that on the abactinal surface. The radial shields are pear-seed shape, about twice as long as broad, separated their whole length by a wedge of scales. The arms are short, about four times the diameter of the disc. There are a pair of short, blunt, stout, rounded mouth-papillæ at the apex of the mouth-angle, and one on either side at the base, which is short, blunt, and leaf-like. The first tentacle-scale is long and spiniform. The mouth-shields are roundly heart-shaped, as broad as long. The side mouth-shields are rather large and broad; they do not meet within. The under arm-plates are squarish, with rounded angles and slightly re-enteringly curved sides; they do not nearly extend across the width of the arm. The upper arm-plates are elliptical, broader than long, almost covering the upper part of the arm. The side arm-plates bear six short, rather stout, bluntly-pointed, subequal arm-spines, the uppermost somewhat smaller than the others and directed upwards. Each tentacle-pore is covered by one large, plain, rounded, leaf-like scale. The colour in life is pale yellowish or greyish white; sometimes the disc is speckled and the rays variegated or banded with dark grey.

Not uncommon near Wellington, among the roots of *Lessonia* and *Macrocystis*.

This species is very nearly allied to *Amphiura constricta*, Lyman. It may be readily distinguished, however, from that species by the size of the upper arm-plates, which extend across nearly the width of the arm; by the form of the radial shields, which are much shorter; and the shape of the mouth-plates.

AMPHIURA ELEGANS, *Leach.*

This little species is abundant on the roots of seaweed in

rock-pools at low water near Gisborne. The specimens collected by me are somewhat smaller than those found in Europe. The colour in life is yellowish or grey, usually vaaiegated or spotted with dark grey.

Ophiopteris antipodium, *Smith.*

A fine specimen of this rare and interesting form was sent me by Mr. Lukins from Nelson. Mr. Lukins notes that it is "rare outside the Boulder Bank, under stones, at low water." The colour of the dried specimen is purplish black with a brownish tinge beneath.

ASTEROIDEA.

Asterias Rodolphi, *Perrier.*

Three specimens of this species were collected by Mr. Danby at Raoul Island; and I am therefore able to add a little to M. Perrier's very brief description (Ann. & Mag. Nat. Hist. ser. 4, vol. xvii. p. 34, 1876).

In the largest specimen, R=95 mm. and r=14 mm.; the number of rays appears to be always seven; they are elongate, cylindrical, tapering towards the extremity, not constricted at the base. There are five somewhat irregular series of spines on the abactinal surface of the rays; those of the median and adjacent series on either side are small and blunt, with granular tips, while those of the outermost series are larger and usually pointed. These larger spines stand upon a regular series of large broad lateral plates, one on every second or third plate. The spines on the disc are small, blunt, and irregularly scattered, sometimes in groups of two or three. All the spines on the abactinal surface are surrounded by wreaths of small forcipiform (crossed) pedicellariæ. There are a few very small sessile forficiform pedicellariæ scattered on the dorsal surface. The marginal plates bear three rather large flattened blunt spines. The armature of the adambulacral plates consists of two small fine cylindrical spines. The madreporic plate is rather small, situated near the edge of the disc. Two of the specimens are dark reddish brown in colour, and the other is pale yellowish, variegated with reddish brown.

This species is nearly allied to *Asterias scabra*, Hutton. The number of rays and series of spines on the rays and the formula of the armature of the marginal and adambulacral plates are the

same in both species. They may be easily distinguished, however, by the difference in size and in the colour of the tube-feet; this latter may be dark in *A. Rodolphi*, but it is certainly not the bright vermilion so strikingly characteristic of the New Zealand species. The skin on the abactinal surface is not so thick, the wreaths of pedicellariæ around the abactinal spines are much smaller, and both kinds of pedicellariæ are smaller and far less numerous than in *A. scabra*.

Asteropsis imperialis, sp. n. (Plate **13**, figs. 1, 2.)

$R=58$ mm.; $r=30$ mm.

Form substellate, flat; interbrachial arcs well rounded. Rays short, broad throughout their length, tapering to a rounded extremity. The plates on the abactinal surface are very irregular; on the disc the larger plates are flat, angular, and connected by smaller narrow plates, forming an irregular broad meshwork; on the rays the plates are somewhat rounded and tumid. The marginal plates are thick and large, overlapping, obliquely placed and somewhat irregular. Those of the superior series on the rays are pear-shaped, becoming roundly oblong and transversely placed in the interbrachial arcs. There are ten or eleven plates between the middle of the interbrachial arc and the tip of the ray, both above and below: the outermost one or two are much smaller than the rest. The plates on the actinal surface of the interbrachial spaces are slightly imbricating, forming a closely packed pavement, but not so regular either in form or disposition as in *A. vernicina*. The adambulacral armature consists of two single series, as in *A. vernicina*; the spines of the furrow series are in pairs (two on each plate); they are rather long, thin, and cylindrical; those of the outer series (actinal spines) are single except near the mouth, where the plates bear two spines each, and there may be a plate here and there further out with two spines; these spines are short, rather stout, somewhat flattened, and bluntly pointed. The whole of the actinal and abactinal surfaces is covered with thin transparent skin. The madreporite is not large, but distinct; it is situated near the centre of the disc. The anal orifice is distinct, situated near the centre of the disc, slightly towards the side distant from the madreporite.

In defining the genera *Asteropsis* and *Dermasterias*, Mr. Sladen

gives as a distinguishing character of the former "a pair of specially localized pedicellariæ at the base of the rays on the abactinal surface" ('Challenger' Report, vol. xxx. p. 355).

I have two specimens of *A. vernicina* from Port Jackson; one of them exhibits no trace of these organs, and the other has a pair of elongate excavate pedicellariæ, with two much depressed valves at the bases of three of the rays; and the other two rays have each but one of these organs. These pedicellariæ are present in *A. imperialis*; but they are irregular in number, size, and situation. Two of the rays have a pair of elongated pedicellariæ situated as those in *A. vernicina*; but one of these rays has also two smaller pedicellariæ nearer the extremity, and the other ray has one; another ray has also two near the base, but one is situated more distally than the other, and they are not so elongate as those on the other rays; and two rays have each but one of these organs. These pedicellariæ are more prominent in this species than in the Australian form.

The colour of *A. imperialis* is brilliant red, variegated on the rays and actinal surface with yellow.

A single example of this fine species was collected by Mr. Danby at Raoul Island.

Gnathaster rugosus, *Hutton*. (Plate **14**. fig. 6.)

I have a very fine specimen of this rare species which was collected at Nelson by Mr. Lukins. Fig. 6, Plate **14**, shows the form and character of the spines on the mouth-plates and the two long spiniform glassy-tipped processes (keels), one on each plate. The specimen is dry, and the spines are somewhat displaced.

Astrogonium sp.

In a previous paper (Trans. N. Z. Inst. vol. xxvii. p. 200) I gave reasons for believing that the form which Prof. Hutton called "*Astrogonium pulchellum*, variety B," would probably prove to be a distinct species. I have since been able to examine a good series of this form, which I have compared with several specimens of *A. pulchellum*; and I find that the differences are so well marked and so constant that I can come to no other conclusion than that it is distinct.

The opinion of Dr. Dendy on the establishment of new species is so good that I take the liberty of quoting it here. The italics

are mine. "In distinguishing species all characters are of use, and a well-marked difference in any one character is, in my opinion, a sufficient justification for a distinct specific name. This, of course, necessitates a good many specific names; but it is better to have too many than too few; and so long as each form is properly described, increase of species only adds to our knowledge, while *the merging of many forms under one name makes hopeless confusion*; for the author who does so seldom thinks it necessary to give an adequate description of each variety; and it then becomes impossible to sort them out and to determine which is really the type of the species." (Trans. Roy. Soc. Victoria, vol. iii. pt. 1, p. 44, 1891.)

I have drawn up a description and figure of this species which I withhold for the present, for it has occurred to me that this may be Gray's species *A. abnormale*, the habitat of which is unknown. Unfortunately I have not seen Gray's description, but only the name in Mr. Sladen's list of known species ('Challenger' Report, vol. xxx. p. 748).

Mr. Lukins has sent me a very fine specimen from Nelson, in which the plates on the dorsal surface are very prominent, almost spherical.

If this be not Gray's *A. abnormale*, I propose that it be called *Astrogonium Huttoni*.

OPHIDIASTER sp.

The collection made by Mr. Danby at the Kermadecs contains four specimens of an *Ophidiaster* which probably belong to one of the following species:—*O. Germani*, Perrier; *O. pusillus*, Müll. & Trosch., *O. cylindricus*, Lamarck. The two former species occur at New Caledonia, and the latter at the Fiji Islands. I have not seen descriptions or figures of any of these, and I cannot therefore identify my specimens.

In the largest specimens $R=120$ mm. and $r=11{\cdot}5$ mm. There are seven regular longitudinal series of granular plates on the rays, and a series of smaller ones on each side of the furrow outside the outer row of spinelets. The outer adambulacral spinelets are very short, blunt, and slightly flattened, and those of the inner or furrow series are similar, but much finer; both series are single. Those of the outer series are surrounded by granules.

The two series are separated by a band of granules ; the granules sometimes extend between the small spinelets of the furrow series. The madreporite is usually nearer the edge of the disc than the centre ; it is distinct and rather large. "Small entrenched pedicellariæ of the characteristic figure-of-eight form" are extremely numerous on the areas between the plates with the granules scattered among them, both on the actinal and abactinal surfaces. The colour in the dried state is yellowish, and in life reddish orange.

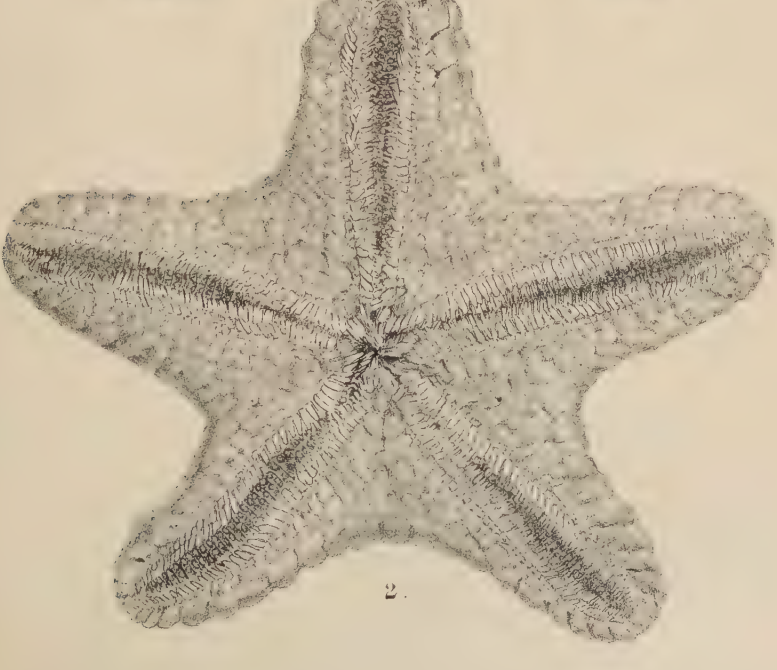
Asterina regularis, *Verrill.*

A number of specimens of this species which I have collected near Wellington shows that it often belies its name. Two of them have seven rays each, five have six rays each, several have more than one madreporite plate; and there is a specimen in the Colonial Museum with eight rays. Several of these are so distinct from normal specimens of *A. regularis*, that if a series were found in a separate locality, a new species might safely be established for them. Prof. Perrier has described another New Zealand species of this genus, *A. novæ-zelandiæ*; but unless it be very different from *A. regularis*, or has been described from a good series showing a constant difference, it may be one of these abnormal forms, which are not uncommon. I stated (Trans. N. Z. Inst. vol. xxvii. p. 199) that this species occurs in Australia. My authority was the 'Alert' Report. Mr. Whitelegge states, however, that it is not found at Port Jackson (Proc. Roy. Soc. N. S. W. vol. xxiii. p. 202, 1889) ; and the "good series" of the 'Alert' Report probably belongs to some other form. I have a series of very fine specimens which were sent to me by Mr. Lukins from Nelson. Amongst these are several with two spines on each of the interradial plates on the actinal surface; others have one spine on the large plates near the mouth and two on the smaller ones near the margin. Not unfrequently the four or five large plates immediately outside the mouth-plates are without spines. The adambulacral plates bear two or three spines, forming a single row in the furrow.

Stichaster polyplax, *Müller & Troschel.*

This is the species which I described under the name *Tarsaster neozelanicus*, Trans. N. Z. Inst. vol. xxvii. p. 207, pl. xii. (1894).

1.



2.

H. F. del. F. H. Michael lith.   Mintern Bros. imp.

ASTEROPSIS IMPERIALIS.

By the examination of living individuals I have recently confirmed my observation that New Zealand specimens, at any rate, have but one papula to each papular area, or occasionally two—a large one and a small one. The character and arrangement of the plates and their armature are also much the same as in the genus *Tarsaster*. As, however, Mr. Sladen, who established the genus *Tarsaster*, has provisionally placed this species in the genus *Stichaster*, I leave it there for the present.

Mr. Suter informs me that Prof. Perrier has recently published a paper on the 'Travailleur' and 'Talisman' Echinoderms, in which he makes proposals for the subdivision of the genus *Stichaster*; but unfortunately I have not seen the paper. I have examined a large series of specimens, some of which were collected by Mr. Lukins at Nelson, and others by Mr. Suter at Sumner and Auckland, and they show clearly that transverse division is characteristic of this species.

STICHASTER SUTERI, *Loriol.*

This species was described by M. de Loriol (Ann. Mus. d'Hist. Nat. de Genève, 1894, p. 477), from specimens sent to the Geneva Museum by Mr. Suter of Christchurch. When I described the same species under the name *Stichaster littoralis*, Trans. N. Z. Inst. vol. xxvii. p. 206, M. de Loriol's paper had not reached New Zealand, and I did not know that any specimens had been sent out of the Colony. There is a difference in the descriptions which requires a word of explanation.

The colour of M. de Loriol's specimens is bright reddish orange, while I have described the species as dark grey. Living individuals are blackish grey; but when placed in spirit this colour rapidly changes to reddish orange. If they are only allowed to remain in the spirit a short time and then dried, the reddish colour is retained; but if they are kept longer in spirit it soon fades, and the specimens become uniform yellowish brown. A similar change of colour occurs in a number of other species—*Stichaster polyplax*, *Asterias calamaria*, and *Asterias scabra*.

I have a specimen of this species collected by Mr. Danby at The Snares. It differs from those obtained on the mainland in the shape of the rays, which are rather longer and taper rapidly to a pointed extremity.

EXPLANATION OF THE PLATES.

PLATE 13.

Fig. 1. *Asteropsis imperialis*, abactinal view, slightly reduced.
2. " " actinal view, slightly reduced.

PLATE 14.

Fig. 1. *Amphiura pusilla*, actinal view, × 16.
2. " " abactinal view, × 16.
3. " " arm-spines, × 16.
4. *Ophiopeza cylindrica*, actinal view, × 7.
5. " " abactinal view of arm, × 7.
6. *Gnathaster rugosus*, mouth-plates, × 7.
7. *Ophiopeza Danbyi*, abactinal view of arm, × 7.
8. " " actinal view of arm, × 7.
9. *Evechinus chloroticus*, spicules of tube-feet, × 65.

New Species of *Perichæta* from New Britain and elsewhere; with some Remarks on certain Diagnostic Characters of the Genus. By Wm. Blaxland Benham, D.Sc. (Lond.), M.A. (Oxon.), Aldrichian Demonstrator in Comparative Anatomy, Oxford.

[Read 4th March, 1897.]

(Plates 15 & 16.)

The paper contains a description of five new species, viz.: *Perichæta novæ britannicæ*, *P. Sedgwickii*, *P. Arturi*, *P. Floweri*, and *P. Madelinæ*, with a description of *P. malamaniensis*, Benham, and, further, some remarks in reply to a criticism by Dr. Michaelsen of statements made by me in reference to the value of certain characters usually regarded as of specific value for the genus *Perichæta*.

Owing to the kindness of Mr. Adam Sedgwick, I am enabled to describe three new species of *Perichæta* which were collected by Dr. Arthur Willey on New Britain, during his excursion amongst the South Sea Islands in search of the eggs of *Nautilus*.

No Earthworms appear to have been recorded from this island; and though they were rather poorly preserved in 70-per-cent. alcohol, I have been able to make out certain interesting peculiarities and novelties. As the number of species of this genus is now getting very large, it is necessary to give very careful

descriptions of all external features that are of diagnostic value; even the colour of preserved specimens is of some aid in distinguishing species; and in order to emphasize the specific characters, I append a "diagnosis" to the description of the individual specimens examined. The lack of this diagnosis in many recent writings renders the matter of comparison extremely laborious; while, on the other hand, a mere formal diagnosis unaccompanied by more detailed description is insufficient. The addition of careful figures of the chief structures is most important, and a comparison with other apparently similar species should not be omitted.

PERICHÆTA NOVÆ BRITANNICÆ, n. sp.

There were fourteen rather stout worms, slightly pointed at each end; of a dark purple-brown colour, without any bands or other markings; the clitellum is a purer brown, marked by two narrow darker bands encircling the body. The posterior region of the body is only slightly lighter than the anterior region, but the last dozen or so segments, as is not unusually the case in this genus, are quite as dark as, or even darker than, the anterior end of the worm. The body-wall behind the clitellum is transparent.

The *length* of the specimens varies from 75 mm. to 180 mm., the average length being 110 mm., with a diameter of 5 mm. The specimen taken for description measures 130 mm., and consists of 120 segments.

The *male pores* are small, circular, and pit-like, situated on slightly raised papillæ, oval in outline (Pl. 15. fig. 1 *a*). Immediately behind each papilla, or "porophore" (as I would term this area which carries the male pore and which is usually glandular, to distinguish it from other variable specific "copulatory papillæ"), is a somewhat crescent-shaped depression, light brown in colour (*s*'), occupying the hinder part of segment XVIII. Just in front of the porophore on segment XVII., behind the chætal ring, is a similarly coloured area, rather more elliptical in shape (*s*). These four marks are very conspicuous, and possibly act as suckers. Further, on each side of each male pore is a small pit-like depression (*p*), one mediad and one laterad of the pore: these are arranged, therefore, much in the same way as in *P. purpurea*, Benham, from Celebes*.

* Ann. & Mag. Nat. Hist. xviii. 1896, p. 429.

The male pores are relatively close together, as there are only four chætæ between them, as counted on the stripped cuticle.

There are two pairs of *spermathecal pores*, between the segments VII./VIII., VIII./IX., appearing as wide conspicuous slits, which under a hand-lens look double, as if each pore led into two ducts. Between these pores are 4 to 6 chætæ. This number is obtained by taking lines joining the two pores of each side and counting the chætæ (on segment VIII.) between these two parallel lines.

The first *dorsal pore* is between segments XII./XIII.: the pores are visible in the clitellar segments of this particular specimen, in which, however, the clitellum is not fully formed.

The *clitellum* occupies the normal position, and there are no chætæ on the segments composing it.

The *chætal ring* is complete, *i. e.* there is neither dorsal nor ventral gap; the chætæ number:—

32	on segment	II.
56	,,	VI.
72	,,	XIII.
74	,,	XXVI.

Internal Anatomy.—There are no particularly stout septa, the four following the gizzard being very little stouter than those behind; but those around the pharynx are, as usual, thick. The gizzard appears to occupy segments IX. and X., there being a short piece of œsophagus in segment VIII., in the place where the gizzard usually commences. The paired cæcum arises in segment XXVII., and extends forwards into segments XXVI. and XXV.; its base, as in a few other species, being deeply notched so as to form four short lobes (fig. 1 *d*). This phenomenon is already recorded in some half a dozen species, in addition to three recently described by myself from Celebes *; but in most of these the lobes are more numerous: in *P. trityphla*, Bedd.†, however, there are only three lobes.

The two *sperm-sacs* on each side are tongue-shaped, not lobed, and lie in the usual segments. There are two pairs of *spermathecæ*, in segments VII. and VIII., opening anteriorly: the thin-walled sac is large and very distinctly marked off from the duct (fig. 1 *c*); it contains a mass of yellowish-white substance (secretion), compacted together to form a somewhat club-shaped

* *Loc. cit.*

† Beddard, P. Z. S. 1896, p. 205.

mass (x); in addition, some flocculent matter lies loose in the sac. The diverticulum is as long as the main sac; it consists of a narrow duct gradually dilating to form an oval swelling at the tip: this is filled with a white mass of spermatozoa (*sp.*).

The *spermiducal gland* (fig. 1 *b*) is nearly rectangular, occupies $2\frac{1}{2}$ segments, viz. XVIII., XVII., and half of XVI., and consists of three main lobes, each of which is lobulated; the whole may be described as "compact." Its duct (*d*) is short, stout, and hardly at all curved. It is directed obliquely inwards and backwards, as it passes away from the gland; it then makes a sudden bend and dips nearly vertically downwards to reach the exterior: there is no muscular bulb.

The species is quite distinct from any other *Perichæta* from this region.

The following may be regarded as the diagnostic characters:—

PERICHÆTA NOVÆ-BRITANNICÆ, n. sp.

Dark purple, without light bands; clitellum brown. Measures 110 mm. × 5 mm.; with 120 segments. Male pores small, circular, on oval papillæ ("porophores"); behind each on XVIII. a curved sucker-like depression; a similar one on XVII. behind the chætæ. Further, small pits, one laterad and one mediad of each pore. Two pairs of spermathecæ, in VIII. and IX., with pores anterior: a large globular sac, with long duct receiving a moderate diverticulum, with short, slightly curved duct slightly dilated distally. Dorsal pore XII./XIII. Chætal ring complete; 56 chætæ in front of, 74 behind, the clitellum. Cæcum with four digitiform secondary lobes; spermiducal gland rectangular, in three segments, short stout duct; no bulb.

Hab. Blanche Bay, Gazelle Peninsula, New Britain.

PERICHÆTA SEDGWICKII, n. sp.

Of this species there were only two very soft specimens, measuring 90 mm. and 110 mm. respectively; the latter is 5 mm. in diameter, and consists of 86 segments.

The *colour* is reddish brown, nearly brick-red, with pale yellowish chætal bands. The dark band is divided into two by a very narrow but distinct pale line in each intersegmental groove. Behind the clitellum, as well as on the first seven segments of the body, there is a distinct but narrow longitudinal streak of darker tint along the mid-dorsal line: the light chætal band is in the anterior segments much broken up by extensions of

the dark bands between individual chætæ. Each dark band extends across the pale ventral surface, but becomes much narrower and lighter in colour as it passes downwards from the sides; this ventral darker band is much broader, although still faint, in segments II., III., IV.

This plan of colouring, in alternate light and dark bands, is very frequent in the genus, and has already been described by several observers for various species.

The *clitellum* does not entirely embrace the usual segments (fig. 2 *b*); it begins behind the chætal ring of segment XIV., and extends only as far as the chætæ on segment XVI. These chætal rings being lighter than the interchætal regions, on first impression—especially to a zoologist who may be only familiar with the subfamily Lumbricidæ—the clitellum appears to occupy two entire segments, but in reality it covers *one whole and two half segments*. The clitellum is fully developed, of the usual thickness, and its margins are quite well marked, and it has the same appearance in both worms. The limited extent of the clitellum recalls *P. mandhorensis*, *P. bermudensis*, and others. There are *complete* circles of chætæ on each of the segments XIV., XV., and XVI.

The *male pores* are small and circular (fig. 2 *a*), on rather prominent papilliform porophores (*po*), of large size, which are separated by 8 chætæ. The prominence of the porophore is in part due to the existence of a horseshoe-shaped depression, deep but narrow, surrounding on three sides the area which carries the pore; it is deeper in front of than behind the porophore, and the free limbs of the horseshoe are directed externally. An examination of the other specimen suggests that it is due to the extension and union of two crescents, one in front and one behind, the porophore, situated apparently intersegmentally, or just on the borders of the segment XVIII. The general description implies an appearance resembling the conditions described for *P. novæ britannicus*; but a comparison of the drawings serves to make clear the differences, and to demonstrate the necessity of such figures to illustrate these small differences, which a mere verbal description is insufficient to convey distinctly to the mind.

In Perrier's *P. aspergillum*, Beddard's *P. bermudensis*, and in Rosa's *P. hippocrepis*, the depression is represented by a series of minute pores or "suckers."

There are three pairs of spermathecal pores situated between

the segments v./vi.. vi./vii., vii./viii., with 13 chætæ on segment vii., between the lines joining the pores.

The first *dorsal pore* is between segments xii./xiii.; the pores are invisible on the clitellum.

The *chætal ring* is not complete: there is a distinct dorsal gap, as may be premised from the existence of the dorsal longitudinal band of colour. There is also a ventral gap, about twice the width of a normal gap.

The chætæ of segments v., vi., vii. are distinctly larger than those on other segments (figs. 2 *e*, 2 *f*), while those of segments iv. and viii. are intermediate in size; in these segments, too, the chætæ are larger on the ventral and lateral surfaces than dorsally. The length of the normal chæta is 0·228 mm., while the larger ones measure 0·341 mm. Similar enlarged chætæ have been described in *P. hawayana*, Rosa, on the 3rd, 4th, and 5th segments, and in *P. sandvicensis*, Bedd., and others.

The chætæ	number	22	on segment	ii.
„	„	29	„	vi.
„	„	44	„	ix.
„	„	50	„	xii.

(The cuticle on segment xiii. was incomplete.) Further back there were 54 on a segment.

Internal Anatomy.—There are no conspicuously stout septa.

The gizzard is tubular, not bell-shaped, and lies in segments viii., ix.

The intestine was so rotten that a touch was sufficient to tear it, and I am not certain whether there are or are not any lateral cæca on the usual segment. I believe, however, that they are absent. But a very exceptional, indeed, I believe, a unique feature in the anatomy of *Perichæta* was observed: viz., the existence of a *median, unpaired, ventral cæcum* in segment xxii. As the worm was opened from the side, in accordance with my usual procedure in dealing with worms of which I have only one or two specimens, this ventral cæcum was at once seen without touching the intestine, but in attempting to search for the normal paired cæcum, the intestinal wall ruptured and broke into pieces.

The vascular system in the anterior part of the body showed up well, on account of the light-brown colour of the blood; the ventral vessel was seen to be double in front of septum ix./x.—as in several other species.

Large "latero-intestinal" hearts occur in segments x. and xi.,

and a still larger one in segment XII.; but in this last, as in the dorsal vessel posterior to this segment, the blood was purple. I have not seen this difference in colour noted before, and I am not able to explain it.

There are three pairs of *spermathecæ*, all alike; the sac is somewhat heart-shaped (fig. 2 *c*), and has a distinct and curved duct, on which is borne a very small sessile globular diverticulum (*div.*). The *spermiducal gland* (fig. 2 *d*) is large and has a very "loose" structure (perhaps due to ill-preservation); it is deeply cleft, and occupies segments XVII., XVIII., and XIX. The duct (*d*) is short and nearly straight, and opens directly to the exterior.

The diagnosis is as follows:—

PERICHÆTA SEDGWICKII, n. sp.

Reddish-brown bands alternating with yellow chætal bands, median dorsal brown stripe; measures 100 mm. × 5 mm., with 86 segments. Clitellum $\overline{\text{XIV.}}$ to $\underline{\text{XVI.}}$, with complete circles of chætæ. Male pore small, on papilliform porophore, surrounded by a horseshoe-shaped deep groove. Three pairs of spermathecæ, in VI., VII., VIII., opening anteriorly; pyriform sac, with long duct, bearing small, globular, sessile diverticulum. Dorsal pore XII./XIII. Chætal ring with dorsal and ventral gaps; 45 chætæ in front of, 54 behind, clitellum; those of segments IV. to VIII. larger than the rest. *A median ventral intestinal cæcum* in XXII. the usual pair of cæca absent (?) Spermiducal gland large, loose, much incised; short, straight duct; no muscular bulb.

Hab. Blanche Bay, New Britain.

Affinities.—There are seven species recorded by Beddard in his monograph, possessing 3 pairs of spermathecæ in segments VI., VII., & VIII., to which four have since been added.

From those with a "short clitellum," viz. *P. bermudensis*, Bedd., *P. mandhorensis*, Mich., *P. hawayana*, Rosa, the present species differs in a number of points.

In *P. bermudensis* nothing is recorded about the colour-banding; there are chætæ only on the last clitellar (16th) segment; enlarged chætæ exist in segments II., III., IV., and various other differences, such as the group of pores round the "porophore." *P. hawayana* differs, too, in the position of the stouter chætæ, in the dorsal pore, the paired cæca, the shape of the sperma-

theca, and several other points. *P. mandhorensis* has long diverticula to the spermathecæ, a long penial duct, paired cæca, and so on.

I consider the facts above recorded to be sufficient to differentiate the present species as distinct—more especially, the peculiar ventral intestinal cæcum and the porophoral area.

PERICHÆTA ARTURI, n. sp.

There were about a dozen specimens of this third species, ranging in length from 70 mm. to 125 mm., with a diameter of about 4 mm. In addition, there are three immature individuals of 50 mm. to 80 mm. in length.

The *colour* of the worm, with the cuticle still on, is violet anteriorly to the clitellum, and brown posteriorly; the clitellum itself is deep purple, with a very narrow nearly white band at each end of it, which is better marked in some specimens than in others. The clitellum occupies the usual segments. After removal of the cuticle the general tint of the body is purple-brown, darker anteriorly, the clitellum is deep brown, and the body greyish brown posteriorly. Thus the violet tinge, so noticeable at first, is due to the cuticle.

There are no chætal bands, the chætæ being set in a ring only very slightly paler than the rest of the surface.

The body-wall is very transparent, even in front of the clitellum.

On stripping off the cuticle, I was astonished to see a long *penis* issue from the male pore—pulled out with the cuticular lining of the penial duct. This penis (Pl. **16**. fig. 4*a*) is a thread-like, cylindrical, slightly-pointed, organ 5 mm. long, so that when pressed forwards it reaches to about the 14th segment.

A penis quite of this kind has not been recorded hitherto in any earthworm, so far as I am aware; but it is almost precisely similar to that of the Leech (*Hirudo*).

The *male pores* are slit-like, on oval, slightly raised porophores, which are separated by twelve chætæ. There are no copulatory papillæ. There is a single pair of *spermathecal pores*, not very evident, between segments VII./VIII., with about 18 chætæ between them.

The series of *dorsal pores* commences between segments XI./XII.

The *chætal ring* is incomplete, presenting a small dorsal gap equal to about twice the usual inter-chætal space; there is no ventral gap. The chætæ of segments v., vi., vii. are larger than the rest, as in the preceding species; while those of segments iv. and viii. are intermediate in size between these and the normal chætæ.

There are no chætæ on the clitellum, which is fully developed.

The chætæ	number	19	on segment	II.
,,	,,	44	,,	VI.
,,	,,	51	,,	XIII.
,,	,,	52	,,	XXVI.

The number of segments in the worm varies considerably, for instance:—

One worm	measuring	70	mm. has	66	segments.
,,	,,	110	,,	88	,,
,,	,,	120	,,	88	,,
,,	,,	125	,,	95	,,
,,	,,	125	,,	100	,,

This slight discrepancy in the relation between length and number of segments suggests that the measurements are not true: the worms are so soft that as one holds them, they stretch to nearly any length. A worm containing 100 segments, for instance, should not measure so much as 125 mm., for the segments are not as much as 1 mm. long, in such a relatively small worm: it is more probable that the true length of each segment is nearer $\frac{3}{4}$ mm., and a worm with this number of segments would be 75 mm. long. Such an estimation of relation of number to length is derived from the study of carefully preserved specimens of other species of *Perichæta*, which have not undergone undue shrinkage.

Internal Anatomy.—The study of the septa in this worm suggests that the usual location of the gizzard in the genus requires further investigation. The peripharyngeal septa are, as usual, fairly stout; the septum between segments vii./viii. is, as usual, distinct and attached to the anterior margin of the gizzard (Pl. 16. fig. 4 *e*); there is also a septum viii./ix., attached to the body-wall at the intersegmental groove, and passing as a delicate sheet of tissue—not a mere strand, as is so often the case—to be inserted in the gizzard, just before its hinder end becomes everted to form the rim of the bell. Septem ix./x. is absent, but the four following septa are quite

thick. The gizzard, therefore, appears to belong almost entirely to segment VIII. (fig. 4 *e*), and scarcely enters the next segment. Its relative size and extent, as well as the fact that there is a normal proportion of œsophagus between it and the septum X./XI., seem to indicate that the gizzard practically belongs to *one segment*, not only in this species, but possibly in others, in which it is variously stated to occupy segments VIII. & IX., or VIII. IX. X., for the reason, chiefly, that there are no septa between these segments and that it occupies nearly, but not quite, the entire space between the septa VII./VIII. and X./XI. There is nearly always a certain amount of œsophagus between the gizzard and this hinder septum (X./XI.), which, in the various species I have dissected, is much larger than it appears to be at first sight.

In his Monograph, Beddard gives as a character of the genus the position of the gizzard in segments VIII., IX., the intervening septum being absent. The fact that the gizzard does lie in the 8th segment in certain species is recorded by Beddard * in *P. Everetti*, *P. pentacystis*, and *P. kinabaluensis*; but the evidence in support of this statement is not given, nor is the fact emphasized, though similar evidence to that just given for the present species is recorded for *P. trityphla*, Bedd. †. Moreover, Rosa ‡ regards the 8th segment as the normal morphological position of the gizzard: he says, in his description of *P. Udei*:

> "Ventriglio grande a tronco di cono, lungo quasi tre segmenti ma anch' esso appartemente morfologicamente al solo segmento 8° perciò il setto rudimentale 8/9 è profondamente infundibulato."

Michaelsen also finds species in which the gizzard is confined to segment VIII.

There is a simple and short intestinal cæcum on each side, arising in segment XXVII., and not extending beyond the preceding segment.

The vascular system is rather instructive. The dorsal vessel, after passing forward through septum X./XI., gives off a small "lateral heart," immediately in front of the septum (*a*, fig. 4 *e*); in front of this another commissural vessel (*b*), not dilated, arises from the dorsal vessel, just behind the gizzard, and presumably

* Annals & Mag. Nat Hist. xvi. 1895, p. 69.

† Proc. Zool. Soc. 1896, p. 205.

‡ Ann. Mus. Civ. Stor. Nat. Genova, (2) xvi. 1896, p. 522.

it belongs to the segment IX.; next, a pair of vessels going to the gizzard itself leave the dorsal trunk immediately anteriorly to the delicate septum VIII./IX., and evidently belong to segment VIII. The next blood-vessel (c) to leave the trunk lies in front of the septum VII./VIII. (quite in front of the gizzard).

The arrangement of the vascular system thus bears out my contention as to the locality of the gizzard, and it will be worth while to examine the distribution of the blood-vessels in this region in cases in which the gizzard appears to lie in more than one segment. Very little has been recorded by recent observers on the arrangement of vessels in *Perichæta*; it has become the fashion to mention the last "heart" only.

The generative organs present a considerable amount of variability. The *spermathecæ* are a pair in segment VIII., opening anteriorly (Pl. 16. fig. 4 d). Normally the sac is globular and smaller than the diverticulum; and the latter is a long cylindrical tube, highly muscular, more or less coiled or undulating, and not dilated at the end. The duct of the sac and the diverticulum appear to communicate in the substance of the body-wall. In one specimen ("B") the spermatheca was much smaller; the diverticulum smaller than the ovoid sac, and evidently empty of spermatozoa: nevertheless this specimen was larger than others in which the spermathecæ were larger. In another specimen opened ("A") the spermathecæ were absent, but in other respects the worm appeared fully developed.

The *spermiducal gland* and copulatory apparatus present a condition which, up to the present time, is unique, I believe, in the genus.

The gland itself, though subject to slight variation in size and proportion, occupies segments XVII., XVIII., and XIX. It consists, normally, of two great squarish lobes, distinctly separated from one another (fig. 4 b). Each lobe is incised round its margin with a few shallow notches: passing from each of these two lobes is a narrow duct; and the two unite to form the "penial duct" (d, fig. 4 c). This is of considerable size and passes directly mediad across the top of a great oval glandulo-muscular sac (b), which is nearly as long as the two lobes of the glands taken together. Having reached nearly to the mediad or internal margin of this sac, it bends sharply upon itself and runs alongside its former course, but extends further outwards, viz. as far as the outer edge of the spermiducal gland itself. This recurrent

limb of the U-shaped duct rests upon a finger-shaped prolongation (c) of the muscular bulb, or glandulo-muscular sac, as it is better to term it, which extends outwards between the two lobes of the gland. In reality, as sections show, the penial duct *enters* the "penial sac" or finger-shaped diverticulum about halfway along its extent, though at first sight the communication appears to be at the tip of the diverticulum. In other specimens

Fig. 1.

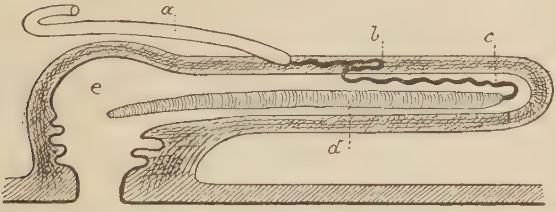
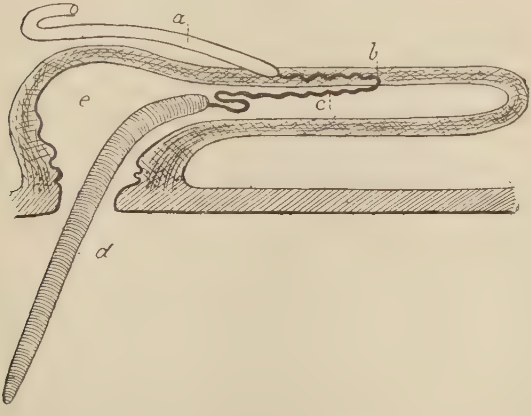


Diagram of a section across the glandulo-muscular sac of the spermiducal gland of *P. Arturi* (*cf.* Pl. **16.** fig. 4 c). The penis at rest. *a.* Penial duct. *b.* Portion of the duct passing through the wall of the penial sac. *c.* Portion of the duct lying free in the "penial sac." *d.* The penis itself. *e.* "Atrium," or cavity of the muscular part of the glandulo-muscular sac.

Fig. 2.



Similar diagram, showing penis protruded. Letters as in Fig. 1. The part of the penial duct (c) has been pulled out by the protrusion of the penis.

the recurrent limb of the penial duct (as in fig. 4 c) did not extend more than halfway along this diverticulum, and this

was the case in the specimen the "penis" of which was drawn out on pealing off the cuticle. Further investigation, as well as a series of sections, shows that the penis is a cylindrical structure, with strongly muscular wall, traversed by two narrow canals—the sperm-duct and duct of the spermiducal gland (text-fig. 3). It lies, when at rest, in the "penial sac" (text-fig. 1), and the penial duct, which passes to it (*b*, *c*), is bent upon itself; when in use, the free end is forced out of the male pore by the contraction of the muscular wall of the sac, and the tube (*c*) simply unbends (text-fig. 2). It is, in fact, a protrusible organ and not an introvert.

Hitherto our ideas upon the "penis" of the genus *Perichæta*, as of other forms with stout "penial ducts," like the Acanthodrilidæ, have been somewhat vague; but it has been presumed that this duct is capable of eversion, *i. e.* it is a "pleurecbolic introvert." In the present instance—as sections of the penis in a condition of retraction and protrusion demonstrate—there is no unfolding of the wall of the penial duct: its free end is merely pushed outwards, in the same manner as the penis of the Leech.

Beddard makes the following remarks in his general account of the "penis" in the Oligochæta, p. 124 of his 'Monograph.' "I have found specimens of *P. Houlleti*, killed in alcohol, with the terminal part of the muscular duct of the spermiducal gland everted. I have not noticed the occurrence of this in allied forms, but it very possibly takes place." . . . "In some species of *Perichæta* the muscular duct of the spermiducal gland opens into a wide and rather thin-walled terminal chamber which opens directly to the exterior: it is here, again, possible that this terminal chamber is protrusible; but I have no facts at hand to prove or disprove the possibility."

The "glandulo-muscular sac" in the present species does not present the firm, compact appearance figured for the "muscular bulb" of other species, which is usually hemispherical and smooth. But the muscular tissue is loose, the fibres not being so definitely arranged in circular and longitudinal series; and further, this sac contains two great oval glands, one in front and the other behind the entrance of the penis (text-fig. 3, *a*, *a′*).

Each gland is a somewhat pear-shaped organ lined by a single layer of tall gland-cells.

Rosa has described, in *P. glandulosa*, a group of conspicuous

glands at the side of the "spermiducal gland," but these are isolated and open by several independent pores around the male

Fig. 3.

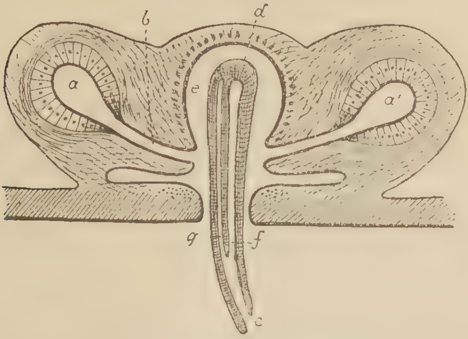


Diagram of a longitudinal section of the glandulo-muscular sac of *P. Arturi*. *a, a'*. The anterior and posterior glands, lined by glandular epithelium. *b*. Duct of gland leading to the "atrium" (*e*). *d*. The end of the protruded penis, cut longitudinally to show the two ducts. *f*. The duct of the spermiducal gland. *g*. The sperm-duct. *c*. External pore, common to *f* and *g*.

pore. In several other species, e. g. *P. aspergillum* and *P. bermudensis*, glands of smaller size similarly open by small isolated pores in this region; but I do not recall any other species of the genus with a "glandulo-muscular" apparatus like that of *P. Arturi*.

The copulatory apparatus amongst Earthworms is very varied, and among those organs which serve as a "penis," that of *Eudrilus* appears to bear most resemblance to that of the present worm; in it a small tongue-shaped papilla, traversed by the sperm-duct, lies, when at rest, in a subspherical muscular sac, as described and figured by Perrier and Beddard and Horst. Beddard has suggested that this papilla or "penis" is capable of protrusion when the muscular sac is everted. Perrier* has figured it protruded, and it is so in a specimen in my possession. It is not only very much smaller than the penis in *P. Arturi*, but its mode of protrusion is evidently quite different, being due to the contraction of the wall of the atrium, and not to the unfolding or straightening of a part of itself. And in other

* Nouv. Arch. Mus. Paris, 1872, pl. 2. fig. 28.

cases the copulatory organ is formed by an eversion of a muscular sac carrying with it the pore of the sperm-duct which traverses its wall, as again in *Moniligaster* *.

I describe another species, *P. malamaniensis* with a penis similar to that of *P. Arturi*.

Amongst the slight variations in structure of this spermiducal gland and apparatus in *P. Arturi* may be mentioned the fact that, in one instance, the gland on one side was very much reduced. In another case it was three-lobed on one side (see Pl. 16. fig. 4 *b*), and the penial duct passed below instead of above the gland, possibly as the result of a sudden contraction or struggle at the death of the worm.

The worm may be characterized as follows :—

PERICHÆTA ARTURI, n. sp.

Violet anteriorly, greyish brown posteriorly. Measures about 100 × 4 mm. (?), with 90 segments. Male pores slit-like, on circular porophores; a long thread-like *penis* protrudes from each on peeling off the cuticle. One pair of spermathecæ in VIII., pore anterior; globular sac, short duct; diverticulum longer than sac, slightly undulating, and scarcely dilated terminally. Dorsal pore XI./XII.

A dorsal gap interrupts the ring of chætæ, which are 50 before and behind the clitellum; those on IV. to VIII. larger. Simple, paired intestinal cæca in XXVII. Spermiducal gland cleft into two quadrate lobes, each much incised; penial duct long, between the lobes, sharply bent in **U**-shape; large glandulo-muscular sac with a prolongation between the lobes of the gland, receiving the penial duct.

Hab. Blanche Bay, Gazelle Peninsula, New Britain.

Affinities.—Of the four species of *Perichæta* enumerated by Beddard as showing a single pair of spermathecæ in segment VIII., none show any close resemblance to the present one; though *P. sangirensis*, M., exhibits at first sight certain general resemblances. A detailed comparison, however, readily distinguishes the two—in coloration and character of spermiducal apparatus; while the spermatheca has a well-marked duct into which the diverticulum opens. In a few general features, too, Rosa's *P. atheca* bears a resemblance.

* Bourne, Qu. Jour. Micr. Sci. xxxvi. pl. 28. fig. 55.

Perichæta malamaniensis.

In 1885, in my earliest contribution to the literature of Earthworms, I referred * (p. 256) to the fact that a species of *Perichæta* from the Philippine Islands presented "numerous nephridia" in each segment. Later †, in 1891, I gave the name *P. malamaniensis* to this species, and was guilty of an indefensible procedure in giving a name to a new worm without a diagnosis of it. This error I propose now to rectify. My attention was drawn to this worm, which I had so long neglected, by coming across some drawings of it, in which I recorded the fact (entirely forgotten) that the spermiducal gland is provided with an exceptionally large muscular sac. I at once concluded, in view of my discovery in *P. Arturi*, that here too I should find a 'penis' of the same character as in that worm.

I consequently re-examined the series of sections which I cut some eleven years ago, with the result that my expectation was confirmed.

PERICHÆTA MALAMANIENSIS, *Benham*, 1891.

The material at my disposal consisted of three worms and a piece, collected during the 'Challenger' expedition at Malamani.

The length of the worm is 90 to 100 mm. with a diameter of about 5 mm.; there are 104 segments.

The worm is dirty yellowish brown, nearly uniform ‡, without chætal bands.

The clitellum is distinctly brown.

The anterior end is rather obtuse; the prostomium is small.

The male pores are slit-like, on rather conspicuous and slightly prominent, but not extensive, "porophores," separated by 10 chætæ; there are no copulatory papillæ. There is a single pair of spermathecal pores between segments VII./VIII. in a line with the male pores. About 15 chætæ measured in segment VIII. lie between the lines joining the pores.

The dorsal pores commence between segments XII./XIII., and are visible on the clitellum, which is quite normal and presents no chætæ.

* Qu. Jour. Micr. Sci. xxvi.

† Qu. Jour. Micr. Sci. xxxii. p. 316.

‡ The worms were in glass-stoppered bottles, so that this colour has nothing to do with the "cork," as Michaelsen has suggested might be the case.

The chætæ are set in a prominent ridge—perhaps due to the excellent preservation of the worm. There is a small dorsal gap, but no ventral one. The chætæ are more closely set ventrally than dorsally.

There are	38	chætæ on	segment	II.
,,	40	,,	,,	V.
,,	54	,,	,,	XII.
,,	62	,,	,,	XXV.

Internal Anatomy.—There is nothing very striking in regard to the septa: septal glands occur in segments IV., V., VI.; the gizzard is relatively large, bell-like in shape, and appears to occupy segments VIII., IX., and X. The intestine is distinctly sacculated after the 14th or 15th segments, but narrows in the 26th and 27th. In the latter segment a pair of large cæca arise, and extend forwards into segment XX.; their lower faces are slightly notched. Behind the 27th segment the intestine again enlarges. Above the intestine, on each side of the dorsal vessel, after the 27th segment, is a pair of racemose ("glycogenic") Phagocytar organs * in each segment, containing abundant pseudonaviculæ.

There is a conspicuously large "heart" in segment XIII., and there are two smaller "hearts" in the preceding segments.

The genital organs present two interesting features, viz.: the very large size of the spermatheca, and the great development of the "muscular bulb" of the spermiducal gland.

The sperm-sacs lie in segments XI. and XII., and the testes in the usual segments.

The spermiducal gland (Pl. 16. fig. 6 *a*) is in two distinct lobes, as in *P. Arturi*, and from each a delicate duct passes away to unite together to form a larger "penial duct," which, after passing some little distance backwards, bends upon itself and becomes much thicker and more muscular (*d*): it then runs forwards to open into the middle of the outer margin of a great glandulo-muscular sac (*b*); this extends from segment XV. to segment XIX. and presents three slightly marked subdivisions, namely, two terminal which contain each a great gland, and a smaller middle one, the "atrium." Sections through this structure show the same general arrangement as in *P. Arturi*—*i. e.*, the penial duct penetrates its wall, and projects freely as a "penis"

* Schneider, Zeitschr. f. wiss. Zool. lxi. 1896. p. 363, describes these organs for *P. indica*.

into the cavity of the "atrium" (text-fig. 4); but, so far as I have been able to make out, the protrusion of the penis is effected in a manner different from that in *P. Arturi.* I find no narrow duct, capable of being unwound in eversion, and I conclude that the sac itself must be everted, as in *Eudrilus*, so that the penis is carried outwards with it.

Fig. 4.

P. malamaniensis.—A diagram of about a third of a transverse section through the body, at the level of the male pore. *a.* Sperm-duct: on the right it is cut through as it passes from the body-wall to the penis, which it traverses to the tip (*cf.* text-fig. 3). *b.* The spermiducal gland. *c.* Its duct. *d.* Muscular penial duct, outside the muscular sac. *d'.* The continuation of this as a narrow, tubular, protrusible penis. *e.* Atrium, or cavity of the muscular part (middle region) of the glandulo-muscular sac (*cf.* Pl. **16.** fig. 6 *a*). *f.* Its muscular wall. *g.* Peculiar muscular pad projecting into the atrium. *h.* Body-wall.

Mr. Beddard, in a recent paper (P. Z. S. 1896), has described an arrangement of the sperm-ducts in relation to the penial duct of *P. Perkinsi,* which he rightly points out (p. 200) has not hitherto been observed. From the observations which I have made, I would suggest that the arrangement here is not so unusual as our lack of information on the microscopical structure of the worms inclines him to consider it to be; for in both the worms which I have recently examined I find essentially

the same thing. In *P. malamaniensis* the sperm-duct crosses the great glandulo-muscular bulb, as ordinary dissection shows, and passes apparently into the narrow duct of the gland (*a*, fig. 6 *a*); but in reality the two sperm-ducts together run alongside this penial duct for some distance, then unite together, and the single sperm-duct accompanies the duct of the gland *throughout the whole length of the penis*, only opening into the gland-duct close to the tip of the latter, where it undergoes a slight dilatation. The conjoined duct now opens by two pores, just below the tip of the penis.

The epithelium of the sperm-duct and gland-duct are quite different, as can readily be distinguished in section. In *P. Arturi* precisely the same thing occurs (text-fig. 3); but, owing to poor condition of preservation, the difference in the lining is not so readily recognized, and if it were not for the observation in *P. malamaniensis* might have been overlooked.

The spermatheca (Pl. 16. fig. 6 *b*) is of considerable size and lies in segment VIII. The sac is large and globular, with a thick muscular duct, nearly as long as itself; into it there opens a small diverticulum, consisting of a slightly undulating muscular duct, terminally dilated to form a small oval sac.

The present species may be diagnosed thus:—

PERICHÆTA MALAMANIENSIS, *Benham*.

Brown; 100 mm. × 5 mm., with 104 segments. Male pores slit-like, separated by 10 chætæ; no copulatory papillæ; a single pair of spermathecæ opening between segments VII./VIII., consisting of an enormous globular sac, with long stout duct, receiving a small diverticulum, terminally dilated. Dorsal pore XII./XIII. Chætal ring with dorsal gap; 50 chætæ in front of and 60 behind the clitellum. Spermiducal gland in two distinct lobes; a glandulo-muscular duct, containing a distinct tubular penis.

Hab. Malamani, Philippine Islands.

Perichæta Floweri and *P. Madelinæ*.

I take this opportunity of describing two other species of *Perichæta* which appear to be new to science. Both were received through the courtesy of Prof. F. J. Bell, for identification, and have been returned to the National Collection. My

thanks are due to the Director of the British Museum of Natural History for the opportunity of examining them.

PERICHÆTA FLOWERI, n. sp.

Three specimens of this worm were collected by a son of Sir W. Flower, at Bukit Timah, Singapore, in some rotting timber.

They were all in a rather poor state of preservation, and indeed one looked as if it had been swallowed by a frog. Of the two which were of use for identification, one measures 120 mm. × 4 mm., and consists of 116 segments; the other is slightly smaller.

In *colour* they are rich brown, though not very dark, with a violet iridescence and nearly white chætal rings. The pre-clitellian region is more distinctly purple than the rest; the clitellum is purplish brown; the ventral surface of the worm is lighter than the dorsal, as is usually the case.

The *male pores* are slit-like, with crenated lips, each on a flat rounded papilla, of a light (in fact nearly white) colour; there are 10 chætæ between these porophores. No copulatory papillæ are present, but one of the "penial ducts" is partially protruded.*

There are four pairs of *spermathecal pores* between segments v./vi., vi./vii., vii./viii., viii./ix.; having about 12 chætæ between, as counted in the 8th segment. The first dorsal pore is between segments xii./xiii.

The *clitellum* does not entirely cover the usual segments, as it does not reach the intersegmental groove at either end; there are about a dozen chætæ on the ventral surface of the 16th segment; there are none on the other clitellar segments.

The *chætal ring* is not quite complete, being interrupted by a small dorsal gap; but there is no perceptible ventral gap.

I counted	18	chætæ	on segment	II.
	35	,,	,,	VI.
	40	,,	,,	XIII.
	45	,,	,,	XXVI.

The chætæ are rather closer together over the ventral surface than dorsally; but none are larger than the rest.

Internal Anatomy.—None of the septa are noticeably thickened; the gizzard and pair of cæca are normal.

* I had returned the specimen to the British Museum before I had examined *P. Arturi*, but from the absence of a muscular bulb I conjecture that there is no "penis."

There are two pairs of large and lobulated sperm-sacs in segments XI. and XII.

The ovisac in segment XIV. is rather large.

There are four pairs of spermathecæ (Pl. **15**. fig. 3 *b*), in segments VI. to IX.; the sac is oval, with a very short duct, indeed scarcely recognizable; the diverticulum is characteristic, having a long, narrow, nearly straight duct, terminating in a globular dilatation.

The spermiducal gland (fig. 3 *a*) is somewhat kidney-shaped in outline, with three deep notches; the penial duct is moderately long, curved, and without a muscular bulb.

The characters of this worm may be summarized as follows:—

P. FLOWERI, n. sp.

Rich brown, with light chætal bands; anterior end purple. Measures 120 × 4 mm., with 116 segments. Male pores slit-like, with crenate lips, on lighter flat porophores separated by 10 chætæ. No copulatory papillæ. Four pairs of spermathecæ, VI. to IX., opening anteriorly. The sac is ovate, with very short duct; diverticulum long, narrow duct, with terminal globular swelling. Dorsal pore XII./XIII. Chætal ring with dorsal gap; 40 chætæ in front of, and 45 behind clitellum. Spermiducal gland oval, with three deep clefts; duct curved, short; no bulb.

Hab. Bukit Timah, Singapore.

Affinities.—There are a considerable number of species with four pairs of spermathecæ; some of these are manifestly different from the present worm. From others it differs in smaller and fewer points. It resembles in several points *P. Perkinsi*, Bedd., from the Sandwich Isles, which, however, has no chætæ on the 16th segment. The spermathecæ appear to be different, if I understand Beddard's description; and though the spermiducal gland bears some likeness, I have not observed the peculiar arrangement of the sperm-ducts described by him *. But in *P. Perkinsi* the chætæ differ in size in various segments, and are larger ventrally than dorsally.

From *P. padasensis*, Bedd., the present worm differs in its much smaller size; in the possession of a very short duct to the spermatheca; in having only two, instead of four pairs of sperm-

* I did not make sections of the worm, and had returned it before I had examined *P. Arturi* and *P. malamaniensis*.

sacs; and in the absence of a muscular bulb to the duct of the spermiducal gland.

P. trinitatis, Bedd., has a clitellum like that of *P. Floweri*; but the "loose" character of the spermiducal gland and the shape of the spermatheca, as well as other characters, serve to distinguish the two.

P. eoa, Rosa, agrees in many points, but the spermiducal gland has a muscular bulb, and is otherwise different; so too is the spermatheca.

P. Floweri agrees in many points with *P. enganensis*, but differs in the chæta-formula, character of cæcum, spermatheca.

P. bosschæ reminds one of the present worm in its general external characters, but there are three pairs of sperm-sacs; the spermiducal gland is different, and the spermathecal diverticulum is only half as long as the main sac.

The other species with four pairs of spermathecæ are mostly characterized by more definite peculiar features, serving to mark them off from the present worm.

PERICHÆTA MADELINÆ, n. sp.

This handsome worm was collected by Mr. Everett on Mt. Kina Balu, Borneo, but it does not appear to be identical with any of those described by Beddard * from the same locality.

The worm (of which I only received a single specimen, which was not fully mature) measures 135 × 6 mm., and consists of 110 segments.

The plan of colouring is similar to that of *P. pulchra*, Mich., *P. zebra*, Benham, and many other species from this part of the world, in having alternate rings of dark and light colour. In the present instance the darker bands, on removal of the cuticle are rich chocolate-brown; the light chætal bands are dead bluish white, without any yellowish tone.

The dark bands, widest dorsally, extend right across the ventral surface as narrow streaks of lighter brown.

At the hinder 18 segments of the worm, as is again very frequently the case, the dark bands are so wide as to meet, sending narrow outgrowths between the individual chetæ and almost obliterating the white bands; on the ventral surface of this region the dark bands are wide, so that the "tail" is darker than the anterior end. The prostomium is margined by white,

* Ann. & Mag. Nat. Hist. (6) xvi. 1895, p. 69.

and the mouth is surrounded by a white ring at the anterior part of segment I.

A dark streak traverses the mid-dorsal line, behind the clitellum, indicating a dorsal gap in the ring of chætæ.

There is nothing to note in respect of the male pores, which are separated by 16 chætæ. There are no special copulatory structures; but the worm was not fully mature, although probably fully grown.

There are four pairs of *spermathecal* pores at the anterior margins of segments VI. to IX., with about 20 chætæ between.

The first *dorsal pore* is between segments XII./XIII., but is small.

The ring of *chætæ* is not complete, there being a dorsal gap equal to about twice the normal interchætal space; but there is no perceptible ventral gap. The chætæ, though showing no difference in size, are closer together ventrally than dorsally; they number

36	in segment	II.
56	„	V.
56	„	X.
66	„	XX.
60	„	XXV.

Internal Anatomy.—There are no remarkably stout septa, though the four following the gizzard are thicker than the rest. The cylindrical gizzard lies in segments VIII. and IX., *i. e.*, there is a portion of œsophagus between it and the septum X./XI.

The cæcum is slightly notched on its ventral surface.

The sperm-sacs present a slight peculiarity, which I do not remember to have noticed before; there is a pair in each of the segments XI., XII.; the "Samenblasen," as usual, being in segments X., XI. Each sperm-sac (Pl. **16**. fig. 5 *c*) is constricted into a larger ventral and medial portion, and a smaller, round, outer portion, which is provided dorsally with a narrow, pointed, finger-shaped prolongation (*f*), quite suddenly and distinctly separated from the rounder sac.

The four pairs of spermathecæ, which are all alike, lie in segments VI. to IX.: each is a pyriform sac (fig. 5 *b*), with a short wide duct, into which opens the duct of the diverticulum: this terminates in a globular swelling.

The spermiducal gland (Pl. **16**. fig. 5 *a*) is nearly square and occupies segments XVI., XVII., and XVIII. Its margin is greatly

incised, so as to be divided up into a number of variously sized lobules. The muscular penial duct (*d*) is S-shaped and opens into a muscular sac or bulb (*b*).

P. MADELINÆ, n. sp.

Alternate bands of purplish chocolate and white. Measures 135 × 6 mm.; 110 segments. Male pores separated by 16 chætæ; no (?) copulatory papillæ. Four pairs of spermathecæ in VI. to IX., opening at the anterior margin. A pyriform sac, with small diverticulum. Dorsal pore XII./XIII. Chætal ring with dorsal gap; 56 chætæ in front of, 60 behind clitellum. Spermiducal gland rectangular, occupying three segments; much and deeply incised: penial duct S-shaped, opening into round muscular bulb.

Hab. Mt. Kina Balu, North Borneo.

Affinities.—Two worms from Kina Balu, viz. *P. Everetti* and *P. kinabaluensis*, are naturally recalled to mind as being, one or the other, possibly identical with the present worm; but in both there are several small spermathecæ in each of the segments VI., VII.—much as in the genera *Kynotus* and *Microchæta*. Further, the normal intestinal cæcum is absent in both; and there are thus fundamental differences. The absence of copulatory papillæ in *P. Madelinæ* must not be taken into account in referring to other worms, for it is not mature, and possibly they may develop late. Only one of Beddard's Bornean species has four pairs of spermathecæ, viz. *P. padasensis*; but in many particulars the two worms differ. I have been unable to find any species which is very near to the present one in the totality of its characters.

Remarks on Michaelsen's Criticism of the value of certain Specific Characters of the Genus Perichæta.

In a short paper dealing with new species of *Perichæta* from Java * I insisted on the necessity for the careful description of certain characters which all lumbricologists recognize as of value in the discrimination of species of this genus, and on the need of careful figures in illustration of these specific characters. In a recent contribution Dr. Michaelsen † discusses my remarks, and

* Ann. & Mag. Nat. Hist. xvi. 1895, p. 40.

† "Oligochæten aus Kükenthal. Ergebn. zool. Forschungsreise in d. Molukken und in Borneo," Abhandl. Senckenb. Gesell. xxiii. Hft. 2, 1896.

to a certain degree appears to have misunderstood the relative value which I set upon these "specific characters."

In writing of *P. capensis* (p. 229) he refers to two new "species," *P. sexta* and *P. Willeyi*, which I founded, but which I pointed out differed but very slightly from *P. capensis* and *P. operculata*. Michaelsen, rightly I think, now unites these and certain other "species" with *P. capensis*, but I see little need for the formation of "subspecies." If they are sufficiently distinct, it seems to me that the term species is as good as a subspecies; and seeing that *P. sexta* and *P. Willeyi* were each founded on one specimen, I should go further than Michaelsen and leave out "subspecies." I suggested (p. 46) that possibly *P. sexta* was a "hybrid" or an abnormal specimen. As Michaelsen has had a greater abundance of material he is in a better position than I was to determine the matter, and the names I used for these two worms must be dropped.

Now, with regard to Michaelsen's criticism of the "specific characters." He takes them, one by one, and shows that each may vary. This, no doubt, is true; but I never intended that any *one* of these characters *by itself* is sufficient to diagnose a species. I merely wished to insist upon special attention being paid to *all* these points, *because they do vary*; and until more trouble is expended on an accurate description of each presumed "new species" we shall not be in a position to decide whether it is or is not a mere variation.

I agree with him fully that colour, or size, or number of segments, and so on, *must be taken with certain anatomical characters*. He points out that colour is no safe guide since it is variable; it may fade on being affected by the discoloration of the spirit by the cork. Quite so. On p. 42 I wrote "no doubt the colours will soon fade in spirit," in referring to the fact that we did not know the colour of the living worm. But I do not believe that the colour-pattern—the characteristic alternate banding of many species—will fade rapidly: the worms we have to deal with now have not usually been in spirit very long; and one can generally see whether fading has or has not taken place to any extent.

Again, with regard to size, I expressly wrote "within certain limits" (p. 47). I meant that, for example, a worm of the size of *P. indica* is not likely to belong to a species which in size is about that of *P. musica*. And there is no doubt that it is some

guide to the identification of a worm to know *about what size* other presumed similar forms may be. The spermatheca is another organ that is of general diagnostic value. Michaelsen remarks, no doubt with truth, that it contracts in spirit. So does the whole body and every organ of the worm; but, nevertheless, the general shape and proportions of sac to diverticulum would not greatly alter. Of much greater importance is the fact that the size depends on the presence of spermatozoa; for we know that in *Lumbricus herculeus* the worm may have fully-developed sperm-sacs and clitelium, but the spermathecæ are frequently extremely minute, even in the freshly-killed worm. Very probably they would be invisible if that worm had been preserved in alcohol; and it is quite within the bounds of probability that *P. atheca*, *P. acystis*, and others, which have been described as being without spermathecæ, are in the condition of the *Lumbricus* just referred to, *i. e.* that the spermathecæ are not yet functional.

Michaelsen also objects to the value of the position of the spermathecæ, whether they lie, for example, in the 7th or the 8th segment, and open to the exterior between these segments. Here, again, variability may occur: a worm with its spermatheca normally in segment 8 may sometimes have it in 7. Several authors have described such variations. Nevertheless, out of the hundreds, or more probably thousands, of specimens of *L. herculeus* that have been opened under my supervision, and have been drawn by students, so that I have been able to note any departures from the normal, I have only noted such variation in the position of the spermathecæ some two or three times. Until we know more of the variability of the animals we are justified in regarding a given position as fixed, if any considerable number of specimens reveal it; and it appears to me that all lumbricologists describing new species should state explicitly the number of specimens they have examined, and should be in a position to state how far such and such an organ is subject to any alteration in size and position.

Too frequently no mention is made of the number of specimens upon which a species is founded; still more frequently a new species is founded for one single specimen. I have done this myself; and it serves to call attention to some new permutation of characters which, later on, may be proved to be mere variations from some well-known "type" species. Michaelsen,

in the paper under review, does note these variations, and makes "subspecies" for what other zoologists, if they had not had a series of specimens to examine, would have termed "new species." With regard, again, to the position of the spermiducal gland and the gizzard. These organs usually appear to occupy more than one segment, but how many segments—if more than one—are morphologically occupied by them is unknown. It appears to me, from my own observations, that each belongs to a single segment—the gizzard to the 8th (as Rosa has suggested), the spermiducal gland to the 18th,—but that each may push the septa limiting the segment backwards and forwards or in both directions. And when we state in a description that the spermiducal gland "occupies three segments," we do so with an idea of conveying the relative size of the organ, and do not intend—as Michaelsen appears to think—to convey the idea that it *belongs morphologically* to these segments. Certain things are postulates of the genus: this is one.

This organ, too, is liable to variation, as I myself have pointed out (*l. c.* p. 43). Again it becomes most necessary to have really careful description and figures of the organ; for there is probably a very fair constancy in the *general* characteristic appearance of the gland, which is more readily expressed by a figure than in words. The minuter lobulation of course varies, but in some species it is very much more extensive than in others; and this is too often expressed by vague terms, such as "compact" or "loosish," without even a statement as to the general outline of the gland, which I still believe, in spite of slight variations, to retain its character. It appears to me, in view of the great number of species in the genus *Perichæta*, that the time has come to insist on these matters. Comparison of "new species" with old ones, and of individuals of the same species with one another, will, I doubt not, reduce the aggregate number of species as more specimens are carefully examined.

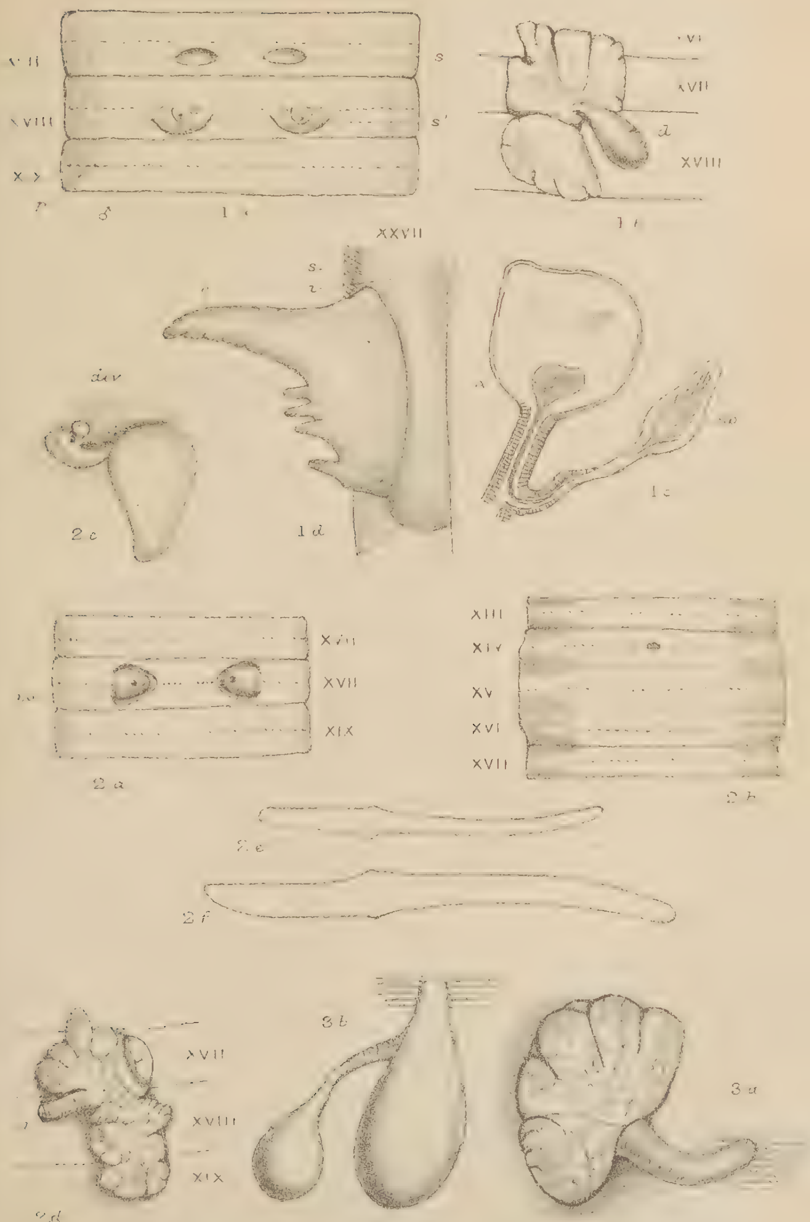
EXPLANATION OF THE PLATES.

Plate 15.

Fig. 1. *Perichæta novæ britannicæ*, n. sp.

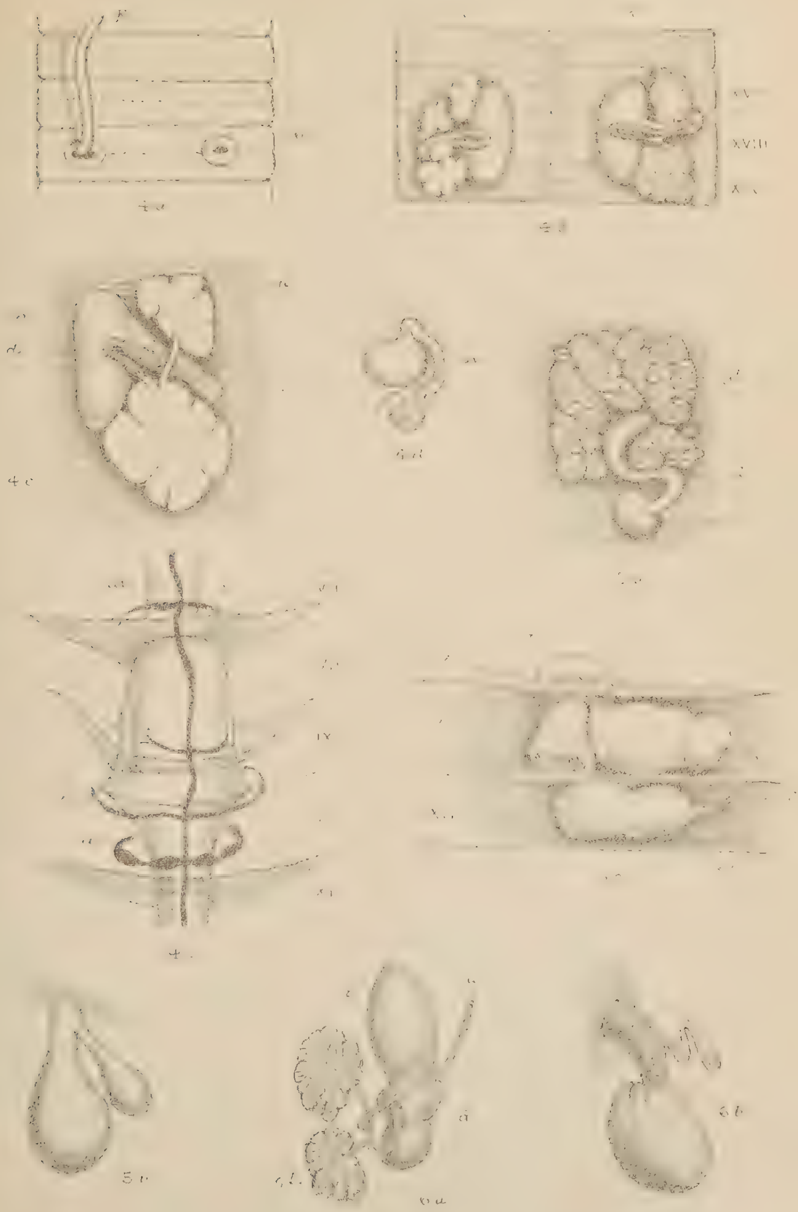
Fig. 1 *a*. View of the male pores and copulatory structures. *s*. Anterior sucker-like organ. *s'*. Posterior sucker-like organ limiting the "porophore," which bears the male pore (♂). *p*. One of the copulatory papillæ, of which there is one each side of each pore.

Fig. 1 *b*. Spermiducal gland. × 4. *d*. Penial duct.



WB.B del. C.Berjeau lith. West, Newman imp.

NEW SPECIES OF PERICHÆTA.



W.B.B. del. C. Berjeau lith. West, Newman imp.

NEW SPECIES OF PERICHÆTA.

Fig. 1 *c.* Spermatheca. *sp.* Spermatozoa in diverticulum. *x.* Coagulated mass in main sac.

Fig. 1 *d.* Cæcum: side view of the intestine (*i*) in segment 27, showing origin and lobulation of the cæcum (*c*). *s.* Septum.

Fig. 2. *Perichæta Sedgwickii*, n. sp.

Fig. 2 *a.* View of male pores. *po.* Porophore surrounded by grooves: the actual pore of sperm-duct is very small.

Fig. 2 *b.* Ventral view of the clitellum. × 3. The body-wall has been slit up and spread out; the "limited" nature of the organ is shown, as well as the existence of complete rings of chætæ in each of its constituent segments.

Fig. 2 *c.* Spermatheca. × 6. *div.* Small, sessile diverticulum.

Fig. 2 *d.* Spermiducal gland. × 4. *d.* Penial duct.

Fig. 2 *e.* Normal chæta from segment XII. × 110.

Fig. 2 *f.* Large chæta from seventh segment. × 110.

Fig. 3. *Perichæta Floweri*, n. sp.

Fig. 3 *a.* Spermiducal gland.

Fig. 3 *b.* Spermatheca.

PLATE 16.

Fig. 4. *Perichæta Arturi*, n. sp.

Fig. 4 *a.* View of the 18th segment, showing the male pores, with the penis (*p*) portruded from one pore. *po.* Porophore. × 6.

Fig. 4 *b.* The pair of spermiducal glands of one specimen in which the penis is at rest. × 4. On the right side is shown the normal shape of the gland: that on the left is abnormal.

Fig. 4 *c.* The spermiducal gland (× 6) of a specimen in which the penis is protruded. *b.* Glandulo-muscular sac. *c.* Its externally directed finger-shaped prolongation, or "penial sac." *d.* The U-shaped penial duct (cf. *a* in text-figs. 1, 2) penetrating the wall of this prolongation. *gl.* The gland.

Fig. 4 *d.* A spermatheca. × 4. *div.* Diverticulum.

Fig. 4 *e.* The gizzard and vascular system of its neighbourhood. A thin but complete septum between segments VIII./IX. is inserted close to the hinder border of the gizzard. *a, b, c.* Commissural vessels. *d.* Dorsal vessel.

Fig. 5. *Perichæta Madelinæ*, n. sp.

Fig. 5 *a.* The spermiducal gland. × 4. *gl.* Gland. *d.* Penial duct. *b.* Muscular bulb (or sac).

Fig. 5 *b.* Spermatheca.

Fig. 5 *c.* The sperm-sacs—to show the peculiar filamentous prolongation (*f*). s^2. The second sperm-sac. *sep.* Septa. r, r^1. Ciliated rosettes in the "capsules" (Samenblasen).

Fig. 6. *Perichæta malamaniensis.*

Fig. 6 *a.* Spermiducal gland. *a.* Sperm-duct. *b.* Glandulo-muscular sac or "atrium." *d.* Penial duct. *gl.* The gland.

Fig. 6 *b.* Spermatheca.

On some new Species of Edriophthalma from the Irish Seas.

By Alfred O. Walker, F.L.S.

[Read 15th April, 1897.]

(Plates 17 & 18.)

Of the four species described in this paper, two, viz. *Leuconopsis ensifer* and *Stenothoë crassicornis*, were taken during the dredging and trawling operations of the Liverpool Marine Biological Committee in April 1896, in the Lancashire Sea Fisheries' steamer 'John Fell.' The steamer was at the time engaged in taking fish for the purpose of obtaining ova for the experimental fish-hatchery at Port Erin, and it was found that by attaching a tow-net with a light cane ring to the back of the trawl-net a short distance behind the "foot rope" many small Crustacea were taken, including the above. The same mode of fishing has also been successfully employed by Mr. R. L. Ascroft, in a trip made by him, in the steam-trawler 'Britannia,' to the northern part of the Bay of Biscay; and it resulted in the capture of some new and rare species of Cumacea and Amphipoda.

Of the other two species, *Apseudes hibernicus* was taken during a week's collecting at Valentia by Mr. F. W. Gamble; while *Parapleustes megacheir* was obtained in the expedition of the Royal Irish Academy, in 1888, and came under my notice while naming the collection of Amphipoda in the Dublin Museum of Science and Art. Until the publication of the Report of the Committee on the Marine Zoology of the Irish Sea, in the British Association Report, 1896, very little had been done in investigating the Edriophthalma of the Irish Seas, except in the neighbourhood of the Isle of Man, where the Liverpool Marine Biological Committee's station at Port Erin had enabled me to collect a large number of species during the last 10 years, all of which (including those taken on the English and Welsh coasts of Liverpool Bay) are published in the above Report. I must not omit to mention an important paper by the Rev. A. M. Norman, F.R.S., on the Cumacea of the 'Lightning,' 'Porcupine,' and 'Valorous' Expeditions, in the Ann. & Mag. Nat. Hist. ser. 5, vol. iii. (1879) p. 54, in which several species from the Irish seas are described or mentioned. I may add that I hope shortly to publish a list of Crustacea from Valentia, with the Isopoda and Amphipoda in the Dublin Museum of Science and Art.

CUMACEA.

Fam. Leuconidæ.

Leuconopsis, n. gen.

A. O. Walker, Report on the Marine Zool. of the Irish Sea, Brit. Assoc. Report for 1896, p. 419 (1897).

Female with a distinct two-jointed appendage to the fourth pair of feet, not furnished with natatory setæ. Lower antennæ short, with the third joint conical, with three minute one-jointed rudimentary flagella. Rami of uropoda subequal.

Male with the third pair of feet each provided on the second joint with a pair of curved blade-like processes.

Remaining characters as in *Leucon*.

Leuconopsis ensifer, *A. O. Walker*. (Pl. **17**. figs. 1–1 *h*.)

Female. Carapace about as long as the free thoracic segments; dorsal crest of fourteen teeth beginning about the middle of the upper margin and curving down to the base of the rostrum; a small tooth on the upper and near the posterior margin; lower margin with the anterior half coarsely toothed and forming with the anterior margin an acute angle, the upper portion of which is finely toothed. Rostrum about a quarter the length of the carapace, obliquely truncate, almost horizontal; lower margin with two or three teeth near the extremity and two or three near the base.

Fourth pair of legs with an exopodite or imperfect natatory appendage, two-jointed, reaching nearly to the end of the first joint, which is as long as the remaining four.

Telson triangular, as in *Leucon*.

Uropoda with peduncle and both rami subequal in length; peduncle almost spineless, inner ramus with six unequal spines on the inner and two on the outer side of the first joint; second joint with two very short spines on the inside; outer ramus obliquely truncate, with five plumose setæ on the inner side and four at the end.

Length $5\frac{1}{2}$ mm.

Male. Upper margin of carapace as long as the free segments; lower margin with five or six teeth on the anterior half, increasing in size anteriorly, forming a right angle with the anterior margin,

which has five teeth just below the rostrum, the second from the rostrum being the largest; rostrum horizontal, blunt, about one-sixth the length of the carapace, with five small teeth on the lower margin.

First pair of legs with seven teeth on the lower margin of the first joint. Second pair with a large spine at the distal end of the second, and two unequally long spines at the end of the third joint. Third pair with an appendage on the second joint, consisting of two parallel curved blades, twice as long as the succeeding three joints.

Length $8\frac{1}{2}$ mm.

The above interesting species has a general resemblance to *Leucon*, from which genus, however, it may be at once distinguished by the appendages on the fourth pair of legs in the female and the third pair in the male. It was taken in the tow-net, attached to the back of the trawl-net, on April 22, 12 miles S.W. of Chicken Rock, 33 fathoms.

Also noticed in the Tenth Annual Report of the Liverpool Marine Biology Committee, and their Biological Station at Port Erin (Isle of Man), p. 14 (1897).

ISOPODA.

Tribe Chelifera.

Fam. Apseudidæ.

Apseudes hibernicus, n. sp. (Pl. **17**. figs. 2–2 *d*; Pl. **18**. figs. 2 *e*, 2 *f*.)

Female. Rostrum triangular, blunt, and depressed at the point, sulcate on the upper surface, without a spine at the point; margins nearly straight. Ocular lobes well developed; eyes rather indistinct. Epistome provided with a strong spine.

Peræon (mesosome) having the 1st segment rather narrower than the cephalosome, with a strong tooth directed forwards on the antero-lateral corner; the dorsal plates of next four segments widely separated; no spines on the ventral surface.

Pleon (metasome) less than $\frac{1}{4}$ the length of the whole animal, about equal to that of the three preceding peræon-segments; epimeral projections obliquely truncate at the ends.

Telson about equal in length to the four preceding pleon-segments, widest in front.

The last three peræon-segments, pleon, and limbs are densely clothed with plumose hairs.

Upper antennæ.—The first joint more than twice as long as the two next, finely granulated on the inner side of the proximal half; flagellum rather longer than the peduncle, 15-jointed; accessory appendage 11-jointed.

Lower antennæ.—First joint more than half as long as the second, 3rd very small, 4th and 5th equal, three times as long as the 3rd; flagellum 11-jointed; antennal scale with 14 setæ.

First legs (chelipedes) as in *A. spinosus* (M. Sars), except that the tooth on the lower margin of the 1st joint is much smaller.

The remaining legs closely resemble those of *A. talpa* (Mont.) and *A. spinosus*, as figured by G. O. Sars respectively in "Middelhavets Saxisopoder" (Archiv for Mathematik og Naturv., B. xi. 1886, p. 263, pl. 2), and 'Crustacea of Norway,' vol. ii. Isopoda, p. 7, pls. i. & ii. The number of spines on the fossorial legs is apt to vary—in the specimen described they differed on each leg.

Uropoda much as in *A. spinosus*; the first three joints of the appendages are much longer than the succeeding ones.

Length 10 mm.

This species is nearest *A. talpa* (Mont.), from which it differs in the form of the rostrum (which wants the spiniform tip figured by G. O. Sars, *l. c.*), in the absence of ventral spines, by the comparative shortness and width of the pleon and telson, and in the form of the latter, which is wider in front than behind, while in *A. talpa* and *A. spinosus* it is the reverse.

A single female was taken by Mr. F. W. Gamble between tide-marks on Church Island, Valentia Harbour, in August 1896. There are also two specimens in the Dublin Museum of Science and Art from the West Coast of Ireland, the exact locality of capture not being known.

AMPHIPODA.

Fam. Stenothoidæ.

Stenothoë crassicornis (Pl. 18. figs. 3–3 *e*), *A. O. Walker*, Brit. Assoc. Rep. for 1896, p. 420 (1897). Also in the Tenth Annual Report of the Liverpool Marine Biology Committee, and their Biological Station at Port Erin (Isle of Man), p. 16 (1897).

Mandibles without a palp.

Maxillipedes with the basal lobe very small, divided to its base.

Antennæ stout, the flagellum of the lower but little longer than the last joint of the peduncle; its first joint almost as long as the remaining four together.

First gnathopods as in *S. marina*.

Second gnathopods with the palm of the propodos defined near the base by a triangular tooth, the distal extremity expanded and cut into four blunt lobes, of which the proximal is much the largest; dactylus with a prominence on the inner margin, coinciding with the palmar lobus.

Peræopods short and strong, the third (meros) joint in the last three pairs much produced backwards, as in *Probolium calcaratum*, G. O. Sars.

Third uropods with four spines on the upper surface of the peduncle, which is twice as long as the first joint of the ramus.

Telson with three pairs of dorsal spines on its proximal half, the first pair the smallest.

Length 2 mm.

In the form of the hand of the second gnathopods this species approaches *S. tenella*, G. O. S., and *S. Dollfusi*, Chevreux; but both these (perhaps identical) species are remarkable for the length and slenderness of their antennæ and peræopods.

Three males taken in the bottom tow-net 6 miles W.S.W. of Calf of Man, in 23 fath., April 22, 1896.

Fam. PARAMPHITHOIDÆ.

PARAPLEUSTES MEGACHEIR, n. sp. (Pl. **18**. figs. 4–4 *c*.)

Body smooth; second segment of pleon (metasome) having a small dorsal tooth, the next three segments dorsally depressed.

Head nearly as long as the first two segments of the peræon (mesosome), lateral and post-antennal angles slight and obtuse. Eyes wanting.

Coxal plates of the first two segments of the peræon small and rhomboidal, with the anterior angle acute, especially in the first; 4th coxal plate wide and as deep as the segment. Third pleon-segment with the lower margin strongly and the hind margin slightly curved; hinder angle obtuse as in *P. pulchellus*, G. O. Sars.

Upper antennæ about two-thirds the length of the body; 1st

joint thick and as long as the next two, 3rd joint much more slender and about one-third the length of the second.

Lower antennæ about three-quarters the length of the upper; last joint of the peduncle rather shorter than the preceding joint.

Maxillipedes strong; dactylus of the palp longer than the preceding joint, very strong, and with a fringe of minute setules on the upper margin; 5th joint much shorter than the 4th.

Gnathopoda very unequal, the propodos of the 1st being about one-fourth of the size of that of the 2nd pair. The first pair have the anterior margin of the 5th joint (propodos) $\frac{1}{3}$ longer than that of the 4th; dactylus about $\frac{2}{3}$ the length of the propodos, the distal half serrate; posterior margin curved, the distal third being minutely crenate, with a spine about one-third of the length from the carpus. The 1st joint is as long as the 5th, the 2nd and 3rd very short; the carpus has the posterior margin convex, setose, with a minute tubercle in the middle.

The second pair have the propodos ovate, longer than the other joints together, having the palm defined by a small tooth two-fifths of the distance from the carpus to the base of the dactylus; the distal portion of the palm is divided into three lobes with crenate edges by two deep sinuses. The setæ on the lobes are of a peculiar form, being divided at some distance from their base into two unequal branches. The first joint is about half as long again as the next three, the carpus being very short, hollowed to receive the base of the propodos, and produced posteriorly.

The peræopoda and third uropoda resemble those of *P. pulchellus*, Sars.

The telson is spoon-shaped and notched at the tip to about one-fourth of its length. This last feature does not agree with Sars's definition of the family (Paramphithoidæ) as having the telson "with the tip not incised." Since, however, the telson itself in other respects, as well as the entire animal, agrees with Sars's description of *Parapleustes*, I am not disposed to make a new genus of it.

Length 8 mm.

This species may be at once distinguished from all others of the genus by the shape and large relative size of the 2nd gnathopods, the disproportion between these and the first pair being much greater even than in *P. latipes* (M. Sars).

Four specimens in the collection of the Dublin Museum of

Science and Art, taken during the expedition of the Royal Irish Academy, 1888, in 750 fath. off the S.W. of Ireland.

EXPLANATION OF THE PLATES.

Plate 17.

Fig. 1. *Leuconopsis ensifer*, n. sp., male (telson wanting). 2 in. objective. (Only one exopodite is shown.)

1 *a*. Anterior margin of cephalothorax, male. 1 in. obj.

1 *b*. Third peræopod without the exopodite, male. 1 in. obj.

1 *c*. Upper antenna of female (½ in.), with the extremity highly magnified (⅛ in.).

1 *d*. Lower antenna of female. ½ in.

1 *e*. First peræopod „ 1 in.

1 *f*. Second „ „ 1 in.

1 *g*. Fourth „ „ ½ in.

1 *h*. Telson and uropoda „ 1 in.

Fig. 2. *Apseudes hibernicus*, n. sp., female. 2 in.

2 *a*. Chelipede of the same. 1 in.

2 *b*. Second (fossorial) leg. „

2 *c*. Third leg. „

2 *d*. Fifth leg. „

Plate 18.

Fig. 2 *e*. Seventh leg of *Apseudes hibernicus* (1 in.), with propodos (½ in.).

2 *f*. Last pleon-segment and telson from below. 1 in.

Fig. 3. *Stenothoë crassicornis*, n. sp. Upper and lower antenna.

3 *a*. Maxillipedes, with basal portion. ⅛ in.

3 *b*. First gnathopod.

3 *c*. Second gnathopod.

3 *d*. Last peræopod.

3 *e*. Urus.

All with ½ in. objective.

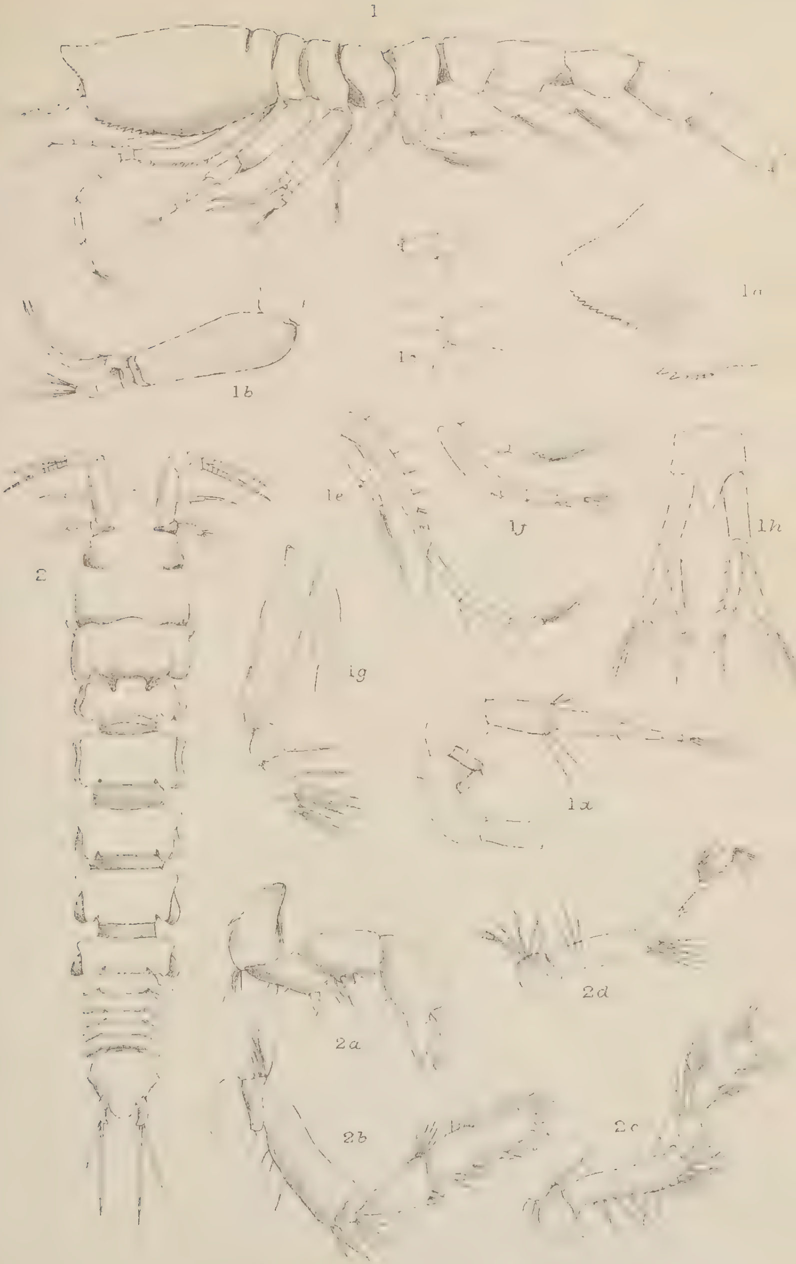
Fig. 4. *Parapleustes megacheir*, n. sp. (peræopods and pleopods omitted). 2 in.

4 *a*. First gnathopod. 2 in.

4 *b*. Second gnathopod. 2 in. 4 *bb*. Distal part of palm. ⅛ in.

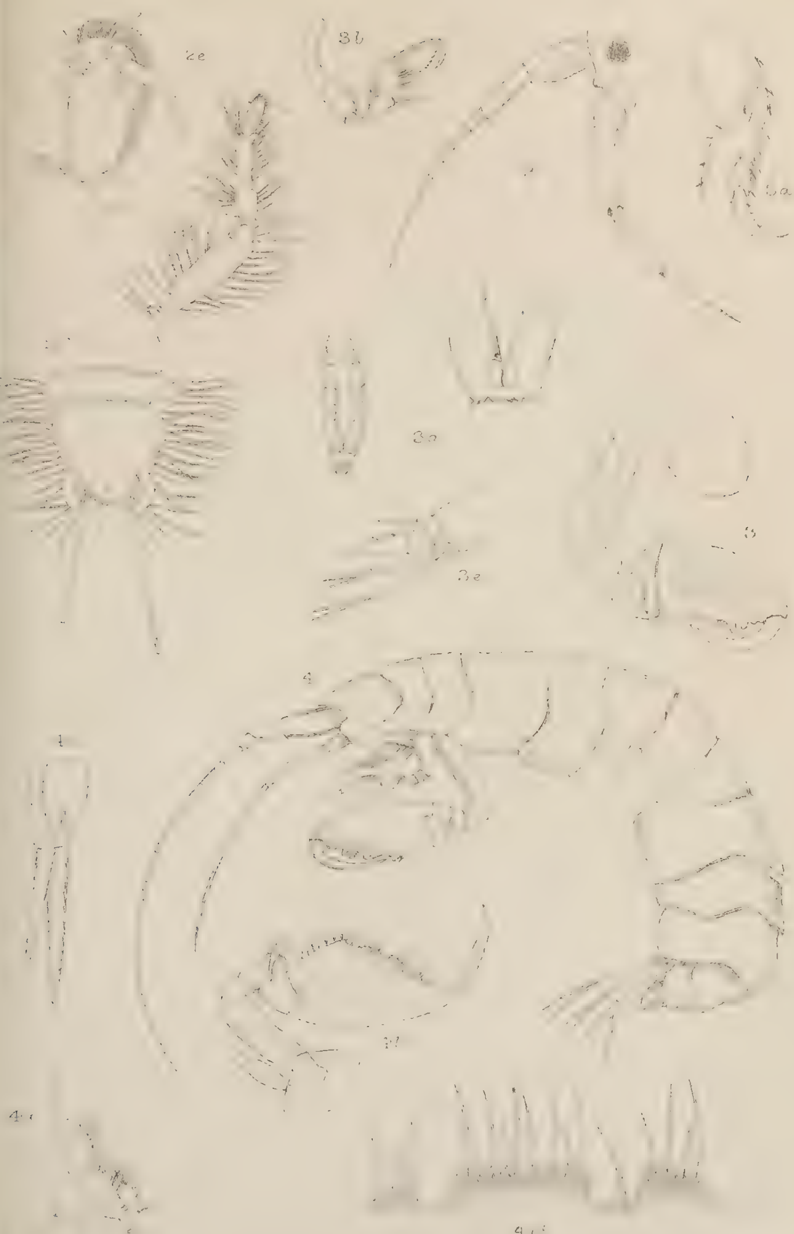
4 *c*. Telson and 3rd uropod. 1 in.

Figs. 2, 2 *f*, 3–3 *e*, 4, and 4 *bb* are drawn on a reduced scale.



A R Hammond lith. West, Newman imp.

NEW SPECIES OF EDRIOPHTHALMA.



A. P. Hammond lith.

West, Newman imp.

NEW SPECIES OF EDRIOPHTHALMA.

On the Marine Mollusca of Madeira; with Descriptions of Thirty-five new Species, and an Index-List of all the known Sea-dwelling Species of that Island. By the Rev. Robert Boog Watson, LL.D., F.R.S.E., F.L.S.

[Read 6th May, 1897.]

(Plates 19 & 20.)

The species here described were chiefly obtained in dredgings which I carried on in Madeira between 1864 and 1874. Much additional material was sent me by my lamented friend the late T. Vernon Wollaston, as executor of the Rev. R. T. Lowe, who dredged and collected from 1826 to 1872, when, with all his treasures of botanical research, he was lost in the Bay of Biscay. Some wreckage on the French coast from the s.s. 'Liberia,' in which Mr. Lowe had sailed for Madeira, was the only record of all on board.

In addition to these gatherings, I have carefully gone over the Mollusca secured by Mr. J. Yate Johnson in his 30 years' study of the various forms of life both in the deeper and shallower waters of the Madeiran sea. It is to his collection that I owe the *Coralliophaga*, which is by far the most important of all the species presented here.

The entire list, including the 35 new species which follow, extends to 382 species.

When not otherwise mentioned, the species here given have been collected by myself; I have been careful to note the fact when this has not been the case.

List of new Species from Madeira.

1. *Cylichna spreta.*
2. *Amphisphyra flava.*
3. *Philine complanata.*
4. —— *trachyostraca.*
5. —— *desmotis.*
6. *Doridium laurentianum.*
7. —— *maderense.*
8. *Pleurobranchus Dautzenbergi.*
9. —— *Lowei.*
10. *Nassa antiquata.*
11. *Murex (Ocinebra) medicago.*
12. *Trophon Lowei.*
13. *Bittium depauperatum.*
14. —— *incile.*
15. *Cæcum atlantidis.*
16. *Natica (Nacca) furva.*
17. *Scalaria rhips.*
18. —— *aspera.*
19. *Scalaria Fischeri.*
20. —— *Smithii.*
21. *Aclis vitrea.*
22. —— *trilineata.*
23. —— *tricarinata.*
24. *Eulima fulva.*
25. —— *sordida.*
26. —— *badia.*
27. —— *rhaphium.*
28. —— *trunca.*
29. —— *inconspicua.*
30. *Odostomia omphaloessa.*
31. —— *(Turbonilla) undata.*
32. *Schismope depressa.*
33. *Montacuta triangularis.*
34. *Coralliophaga Johnsoni.*
35. *Teredo Dallii.*

Fam. Scaphandridæ.

Gen. Cylichna, *Lov.*

1.* Cylichna spreta, n. sp.

Shell smallish, oval, somewhat broad just below the middle and contracted upwards, truncated above, where the edge is carinated and thickened but not furrowed. *Longitudinals*: the lines of growth are very faint, delicate, close-set, and hair-like. *Spirals*: there are very slight and superficial microscopic scratches which extend to the whole surface. *Colour* dull pellucid white. *Mouth* club-shaped, bent, narrow above, widened but drawn out and lop-sided in front. *Outer lip* rising from the outer edge of the apex, bends back, and with a slightly patulous front makes a minute semicircular sweep round the top, whence with a slight divergence in its direction to the right it runs straight forward, with a barely retreating edge, till it nears the point of the shell, where scarcely patulous it sweeps round and merges with a very faint twist into the point of the pillar, continued up the body as a mere film to its junction with the outer lip. *Apex*, which is contracted and small, consists of the round edge which is thickened by a pad within the shell, in the centre is a somewhat abrupt minute pore.—L. 0·09 in. B. 0·05.

This species a good deal resembles the young shell of *C. ovata*, Jeffr., but has the mouth more bent, the swell of the body-whorl lies higher and is not so large, while the apex and the front of the shell are smaller; the apical pore is also more contracted.

The few specimens of this species I got from about 30 to 40 fms. off Porto Santo; they are nearly all quite young shells.

Gen. Amphisphyra, *Lov.*

2. Amphisphyra flava, n. sp.

Shell globose, thin, glossy, brownish yellow, with large open mouth and a hidden spire. *Sculpture*: there are faint soft longitudinal undulations, and, like these, following the lines of growth are very fine silky striations with a mere suggestion of spirals in the structure of the shell. *Colour* yellowish with a faint tinge of ruddyish brown. *Spire* very small, and sunk in a minute pore-like depression. *Whorls*: that of the body, which is alone visible, is shortly globose above, but, below this, on the left is hard twisted in round the pillar, while, in forming the

* These numbers correspond with those of the figures on Plates **19** and **20**.

mouth, it sweeps widely and freely away to the right. *Outer lip*: it rises in the young shell barely perceptibly (in the older shell, not at all) above the apex, with very little of an advancing edge, and forming no sinus it turns at an obtuse angle and advances a little obliquely but in a straight direction to the periphery, from which, neither contracted nor expanded but retaining its forward edge, it slopes slightly backwards, and then makes a great patulous sweep round the base out to the left of the pillar, from the tip of which, with a free circular sweep, its sharp edge bends round to join the body, leaving behind it a narrow groove and an open-mouthed, but minute, umbilical depression, above which to the apex the mouth-edge is defined by a broadish-spread, thin, whity film.—H. 0·133. B. 0·13.

From Funchal Bay along the S. coast eastward to Punta São Lourenço down to 50 fms.; rare. Mr. Johnson got one specimen; I several, but chiefly young. It resembles *A. globosa*, Lov., but differs in colour, in smaller body, in larger opener mouth, in flatter top, and in sunken apex.

Fam. PHILINIDÆ.

Gen. PHILINE, *Asc.*

3. PHILINE COMPLANATA, n. sp.

Shell thin, tumid, smooth, a little oblique in form, and with a flattened top. *Sculpture*: rather feeble, close, irregular lines of growth. *Colour* pure white, translucent, not glossy. *Spire* tabulated, nucleus slightly impressed, but the rest of the spire becomes gradually a very little prominent. *Whorls* two and a half, with a small mammillary nucleus. *Mouth* pear-shaped. *Outer lip* open: it springs from slightly below the top edge, advancing a very little, it curves at the top freely round and then runs downward straight, but in its direction a little obliquely towards the right; across the base it sweeps with a free curve, is a little patulous, and on the left rises to join the point of the pillar, which is barely if at all prominent. *Inner lip* more or less curved; it runs a little obliquely but in a line of increasing straightness, carrying the thin glaze spread on the body across to the sharp-edged curved pillar, leaving behind it a minute chink and a mere suggestion of an umbilicus.—L. 0·1. B. 0·067.

Funchal Bay, 50 fms.

This species resembles *P. finmarchica*, M. Sars, but is smaller,

less tumid, and the outer lip does not, as in that species, rise above the crown except, and but occasionally, in the very young shell: the sculpture too is quite different.

4. PHILINE TRACHYOSTRACA, n. sp. (τραχυόστρακος, rough-shelled.)

Shell oval, but slightly truncated across the top, flattened, thin, translucent, very rough and fretted on the outside surface. *Sculpture*: the whole surface is very harshly roughened by a network of coarse, sharp, narrow, unequal projecting bars, which give a crusted appearance to the shell; where this network is rubbed off the surface of the shell appears like frosted glass fretted in squares: the longitudinal bars run on the lines of growth, those which cross them are spirals. *Colour*: the surface made up of the bars is dead dirty white. *Spire*: a little sunken; in the bottom of a small, open, funnel-shaped depression is the mammillary apex, round which coil two whorls. *Suture* barely impressed. *Mouth* pear-shaped, rather small. *Outer lip* rises shortly, makes a short and narrow curve at the top, runs down with a hardly prominent edge and but slight curve to the base, where it sweeps round freely (but is barely patulous) to join the point of the pillar. *Inner lip*: down the body from well inside the mouth this lip projects as a narrow square-set shelf, which dies off on the straight longish sharp-edged pillar, which is slightly truncate at its point.—L. 0·11. B. 0·07.

Of this curiously marked *Philine* I got only two specimens, one of them young—both from about 50 fms. Funchal Bay.

5. PHILINE DESMOTIS, n. sp. (δεσμῶτις, enchained.)

Shell rhomboidal, but with the upper left-hand corner rounded off; flattened, thin, but not fragile, horny, hardly glossy. *Sculpture*: there are many unequal and somewhat irregular lines of growth, coincident with whose curves are very fine microscopic lines which seem to pervade the substance of the shell; crossing these nearly at a right angle are impressed chain-like lines whose links are 3 to 4 times as long as they are broad, towards the lower edge of the shell these links are more and more elongated, the raised surfaces between the chains are slightly wider than the chain lines, and project on the edge of the shell which they crenellate strongly above, more feebly but still more or less traceably, especially in the young shell, all along its whole edge; a slight translucent pad encircles the top of the shell. *Colour*

white, somewhat opaque, and with a yellowish tinge. *Spire* not in the least prominent, the apex being small, mammiform, and slightly sunken; round it rapidly enlarging, and defined by a small slightly impressed suture, coils a single whorl whose upper narrow, flattened but rounded edge slightly overtops the apex. *Mouth* very large, being about 4 times as broad as the body, narrowing above, it is very wide and scoop-like in front. *Outer lip* perfectly straight and parallel to the axis, at the top and at the base it turns quickly but roundly and a little patulously to join the spire. *Inner lip* has a narrow thin appressed glaze across the upper part of the very slightly oblique body; after the glaze dies out, the thin sharp lip runs on with a slight twist to join the outer edge of the shell.—L. 0·07; do. of the body-whorl 0·05. B. 0·056.

Punta de São Lourenço, Santa Cruz, Porto Santo, to 50 fms. Not rare.

In shape this species is very like the young of *P. aperta* (L.), but is slightly narrower; the outer lip does not rise so high as in that species; the body-whorl is slightly narrower, longer, and more parallel to the axis: texture and sculpture are of course quite different, and the full-grown shells are utterly unlike. Than *P. scabra*, Müll., this is broader, the top does not slope obliquely down to the right; the body-whorl is narrower and not so much swoln to the right, and its direction being more oblique the shell is more narrowed upwards; the whole front of the shell below is wider, opener, more scoop-shaped. The chain-link sculpture is in a single row, and is only doubled when a fresh row first begins to appear: the links are fully 3 times as long as they are broad. Than *P. catena*, Mont., this is much wider, opener, and straighter; the sculpture-chains are more distant from each other, and the links are smaller and longer. *P. Loveni*, Malm, is much narrower, has a larger body-whorl; the outer lip falls much short of the apex, the chain-sculpture is double, and the links are much shorter. *P. cingulata*, Sars, and *P. quadrata*, Wood, differ much from this both in form and sculpture.

Fam. Doridiidæ.

Gen. Doridium, *Meckel*.

6. Doridium (?) laurentianum, n. sp. (Not figured.)

Body unknown.

Shell small, but relatively to its size strong, somewhat flattened

on both faces; outline trapezoidal, the front and back lines being fairly parallel, though somewhat converging upward (*i. e.* where the head of the animal would be); the lower edge is rounded; the top of the shell is produced into a short oblique wing-like extension, from which four to six short small bluntish points project. This wing-like projection slopes downward to the left towards the somewhat unformed nuclear top of the pillar, from which it is separated by a small rounded sinus with a reverted edge; below the nuclear pad the lip-edge is broadly but shortly reverted, leaving behind it on the left a well-marked very oblique umbilical furrow; the whole mouth-edge is strong; the front face of the shell is slightly concave, the back is rather flatly convex. The surface of the shell is somewhat rudely marked by lines of growth, and microscopic, close-set, faint, regular longitudinal markings can just be traced; the colour is translucent white, only the embryonic knob is brownish and of a limy texture.

The living animal I never found, and only four minute shells presented themselves in dredgings of 50 fms. from Punta de São Lourenço, whence the specific name is taken.—L. 0·06. B. 0·036. They are probably *Doridiums*. Of the four specimens, two were unfortunately lost by a friend.

7. Doridium maderense, n. sp. (Figs. 7, 7 *a*, 7 *b*.)

Body about half an inch in length and a third of an inch in breadth; it is well arched; the foot is oval in contour, with the mantle-covered square-fronted body just perceptibly projecting in front; while the tail, which is short, square, abruptly truncated, hardly bifid, but with a slight tubercular prominence at either corner, is more prominent behind; there is no flagelliform appendix; the entire head is covered by the unbroken mantle which extends over the body, either side of which is inlapped by the mantle-flaps, as in *Philine*; in the substance of the tail the shell can be distinctly seen with the spire directed towards the animal's head, while in the body, rather on the left side, can be traced (what is apparently the stomach and entrails) a slightly opaque, elongately oval substance defined by a brownish outline, but varying slightly in form and position. I failed to detect either the branchial plume or the vent, though there is no membranous lobe to hide these as in *D. carnosum*, Cuv. (see Veyssière, Tectibranches, p. 48, pl. ii. 42). *Colour*: the whole animal is opaque (or rather not quite translucent) white, dotted, especially

on the foot, with a very few and extremely minute specks of crimson, and each of the two tail-tips has a bright but minute crimson fleck. Preserved in spirit, the animal's colour changed to a uniform brownish-black.

Shell: in shape like one outspread wing and tail of a bird which has been cut longitudinally through the middle; in the centre there is a small thickened nucleus, with a short pillar and an open coil of one and a half whorls. In *substance*, *colour*, and *ornamentation* it is much like the shell of *Philine scabra*, Müll., or *P. punctata*, Clerk. A fine but distinct marginal bar of somewhat varying strength, beaded on the outer face and projecting sharply on the inner face of the shell, runs round nearly the whole edge, and three or four others occur at somewhat irregular intervals between the upper and lower edges of the shell. Besides these there are many spiral and longitudinal undulations with much finer rounded spirals.—L. (body) half an inch, B. 0·3. Shell, L. 0·09, B. 0·065.

Funchal, Punta de São Lourenço, Caniçal. From shallow water to 50 fms.

The shells of this species I found not unfrequently, but only one living animal presented itself. It lived with me for some days. I never saw it swim—it always crawled, and then never on the surface of the sand of the bottom; as soon as it could it passed in just below the surface, burrowing not deeply, but forcing the sand to rise and pass over its back in a way very curious.

Cf. *Acera marmorata*, Cantraine, Malac. Médit. p. 73, ii. 2. *Doridium carnosum*, Cuvier, and *D. membranaceum*, Meckel, Veyssière, Moll. Opisthobranches, pp. 41–49, pl. ii. 42–47.

Fam. PLEUROBRANCHIDÆ.

Gen. PLEUROBRANCHUS, *Cuv.*

8. PLEUROBRANCHUS DAUTZENBERGI, n. sp.

Shell oval, flattened, fairly strong, white, dull outside but glossy within. *Sculpture*: strongish, irregular and unequal lines of growth, with longitudinal striæ, similar to but keener than those of *P. plumula*; the oblique furrow of that species is entirely absent. *Colour* semitransparent to opaque yellowish white. *Spire*: a small rounded knob lying well over to the right and bent down on the back of the shell so as to be quite

dominated by the further growth of the first whorl, which rises up on the left and forms the most prominent part of the shell at this end as it turns over with a sharp twist and encloses a small pear-shaped body-space within the *inner lip*, which, with a sharp finely-projecting edge, sweeps freely round and, slightly expanding, runs straight down to the base, where, scoop-like and with a semicircular curve, it passes round to form the sharp, barely curved *outer lip*, which, parallel to the other, rises to or nearly to the full height of the apex, leaving, however, a small nick at its junction with the apical whorl.—L. 0·18. B. 0·11.

A well-marked species, to which I have attached the name of M. Ph. Dautzenberg, who, in conjunction with M. Henri Fischer, is so ably working out the Prince of Monaco's dredgings in the 'Hirondelle' and the 'Princesse Alice' at the Azores.

The species is not very common. I have the two specimens of it got by the Rev. R. T. Lowe in 1829 at Magdalena. Another of his specimens and a few of mine came from near Funchal, but most of mine and one of his came from the east end of the south shore towards Punta de São Lourenço.

Mr. Lowe has a note on the living specimen which he got at the Gorgulho, near Funchal, that the "animal was white, subpellucid, about $\frac{1}{3}$ in. long," that "the edges of the mantle were loose and floating, as in *Sigaretus*"; the branchiæ he says he had not seen.

9. Pleurobranchus Lowei, n. sp.

Shell strong, shallow, long, narrow-pointed and gathered in at the caudal end, broad, flat and open at the cephalic end, with nearly straight sides. *Colour* white and translucent. *Sculpture* fine sharpish regular lines of growth; of longitudinals, a suggestion is traceable under the microscope in exceptionally good light—a very faint trace of such a diagonal impression as forms so marked a feature in *P. plumula*, Mont., is visible on the outside and shows more distinctly in the interior. *Spire* consists of $3\frac{1}{2}$ well-rounded whorls parted by a distinct impressed, slightly marginated suture; the apex lies flat on the back of the shell and a little behind the extreme point; the tip is minute, rounded, and glossy, of a pale ruddy-brownish colour; from this point the two sides slope away as a cloak hangs on a peg, and the back of the shell is here well rounded. *Mouth* spreads fully open but for the small, long, narrow curved chamber which lies in under the spire and the edge of the inner lip. *Outer lip* rises

almost to the point of the shell, runs slightly obliquely towards the right, then, with scarcely an angulation, it runs straight forward, sweeps quite patulously in a semicircle round the front, and so with a very gentle curve the inner lip, sharp-edged and a little prominent, rises to the top, where it makes a quicker curve, and then turns almost at a right angle in the line of axis to join the base of the spire, where it leaves but half conceals a small shallow umbilicus, round which the lines of growth appear as strongish wrinkles, and the traces of longitudinal striæ in exceptionally good light seemed faintly more definite.—L. 0·35. B. 0·17.

Of this species Mr. Lowe, in 1827, got one good specimen at Labra, near Punta de São Lourenço, to the east of which I got a quite unmistakable fragment. These, so far as known to me, are the only representatives of this well-marked species.

Fam. NASSIDÆ.

Gen. NASSA, *Lam.*

10. NASSA ANTIQUATA, n. sp.

Shell small, strongish, pale brownish white flecked with chocolate-brown, compact, with a rather tall conical spire, a small closely-coiled turbinated apex, a short conical rounded base, a very short but strong pillar. *Sculpture—Longitudinals*: on the first three normal whorls are about 9 rather feeble ribs, helped to prominence by a row of nearly adjacent small flattened tubercles which run down them; on the lower whorls these riblets disappear and only close sharp lines of growth appear, which come to strength on the base but especially behind the outer lip, where there is a flat strongish rather remote callus. *Spirals*: below the suture there is a small, flat, slightly raised ribbon defined on its lower side by a distinct stippled furrow; this ribbon and furrow begin to show on the third regular whorl, but are barely traceable on the external callus of the outer lip; on each of the upper regular whorls there are three pronounced rounded threads, rising where they cross the ribs into tubercles and separated from one another by narrow furrows; these spiral threads are barely traceable on the intermediate whorls, but to the number of 9 or 10 become strong and crowded on the base; at the point is a strong furrow, and below it a thread twisting round the pillar and defining the canal; below it the pillar is scored by about six threads and weak furrows. *Colour* a very pale ruddy brownish

white, which is porcellanous on the pillar and in the mouth. *Spire* somewhat tall, conical, with hardly convex profile-lines. *Apex* small, pellucid white, consisting of three compact, turbinated, slightly swoln, smooth whorls, the extreme tip of which is very small. *Whorls* 9, conical, almost straight-sided, not constricted below, with a short rounded base. *Suture* linear, scarcely impressed, but distinct from a slight prominence of the subjacent whorl. *Mouth* oval, short, not expanding, channelled above but not in the lip; the canal at the pillar is narrow and deep, it is inclined to the left and widens as it advances. *Outer lip* nearly semicircular, but its curve is slightly flattened above and intensified in passing round to the base; it has a little way within the mouth about 10 teeth, of which one at the top, two in the middle, and one at the edge of the canal are strongish; the others are small, but all run some way into the mouth. *Inner lip* well reverted and thickened, with an abrupt edge across the body; on the base and down the pillar it leaves a small umbilical chink behind it; just within the mouth it bears a few flattened tubercles, which vary in number and size; the tip of the pillar is well flanged along the canal-edge.—L. 0·45. B. 0·22.

Rare—Funchal and Cabo Girão (*Lowe*, *Watson*).

None of the *Nassas* of our seas resemble this species, differing as it does from them in its narrow compact form and in its sculpture. Judging from figures, *N. glabrata*, A. Ad., from the Pacific is a good deal like in many ways, in some of its forms especially. Amidst the inconceivable multitude of Ligurian Tertiary forms figured by Bellardi it seemed probable that this species might be found, but nothing satisfactory presents itself there, nor elsewhere has the search among Tertiary fossils been successful, though diligently prosecuted. I do not attempt a comparison of it with *N. semistriata*, Broc., nor with *N. labiosa*, J. Sow., nor with the *N. corniculum*, Olivi, nor with the *N. trifasciata*, A. Ad., nor with the *N. Gallandiana*, Fischer, for the relation of these species has become more and more impossible for off-hand treatment.

Fam. MURICIDÆ.

Gen. MUREX, *L.*

11. MUREX (OCINEBRA) MEDICAGO, n. sp.

Shell strongish, pale brown, rather stumpily biconical, with a

tallish scalar spire, spinous whorls, a small but coarse tip, a shortish base, and a flattened snout. *Sculpture—Longitudinals*: there are no varices, but on each whorl 7 to 8 quite distinct rounded ribs, which are made prominent by the small, open, internally imbricated, upturned prickles, of which a prominent series crowns each whorl at its shoulder a little below the suture; others similar, but smaller, crest each spiral as it crosses the successive longitudinals; the whole surface is covered with sharp, thin, continuous forward-facing laminæ, not close-set but somewhat crowded and imbricated on the crest of the ribs. *Spirals*: there are 5 to 6 well-marked spiral threads on the last whorl, about 3 on the penultimate, and 2 on the earlier whorls; the first, which forms the shoulder, lies a little remote from the suture; the twisted snout is scored by the strong-vaulted old-canal scars. *Colour* pale slightly ruddy brown, paler on the tip and on the spines. *Spire* rather high, conical, subscalar. *Apex* is small, but not fine nor sharp; it consists of $1\frac{1}{2}$ whorls, which in very young and perfect specimens appear faintly ribbed; the extreme tip is semi-immersed. *Whorls* 7 to 8 in all; they are flattened and very slightly declining from the suture to the shoulder, from below which they are rounded and contracted on the base to the somewhat small flattened and triangularly-shaped snout, the point of which is slightly reverted and emarginated. *Suture* indistinct. *Mouth* narrowly oval, rounded and patulous above; in front there is a rather narrow, oblique, open canal. *Outer lip* barely patulous, well arched, thin on the edge; within it has a feeble varix near the edge with 5 to 6 rounded but rather feeble teeth. *Inner lip* with a slightly projecting thin edge; it forms a continuous curve across the body and then straight down the pillar, the point of which is cut off abruptly and obliquely at the canal, over which the edge projects sharply but without closing it in; between this edge and the old canal-swelling is a very slight and open furrow.—H. 0·6. B. 0·3.

Not common. Madeira, Punta de Lourenço to 50 fms.; Magdalena (dredged); Selvagem Grande, shore (*Lowe*, *Watson*).

This species somewhat resembles *Trophon Lowei*, Wats., but the shape of the whorls, of the apex, and of the mouth, as well as the sculpture and colour, are different. *Murex cristatus*, Broc., resembles it most, but is narrower and differs in shape of whorls, in sculpture, and in colour.

Gen. Trophon, *Montfort.*

12. Trophon Lowei, n. sp.

Shell strong, biconical, with a straight-sided spire and a very small glassy turbinated tip; the snout is shortish but small. *Sculpture—Longitudinals*: there are 7 strong, rounded, slightly shouldered ribs which run continuously down the spire; they rather tend to multiply towards the tip, where they pass into being round tubercles; they are parted by slightly narrower, shallow, rounded and open furrows; these, as well as the ribs, are closely scored with small superficial harsh lines. *Spirals*: there are on the body-whorl 12 to 15 narrow, slightly raised threads, roughened but not squamated by the crossing of the longitudinal threads; they are chestnut-tinted, with flattened interspaces of about twice their breadth; in each of these lie more or less distinct smaller threads which are occasionally double; a fine rounded thread encircles the top of each embryonic whorl, but tends to die out in the later whorls. *Colour* yellowish grey, with chestnut tint on the spirals. *Spire* straight-sided, conical, slightly higher than its breadth above the body-whorl; in its upper part slightly scalar; the tip is sharp, very small and prominent, and consists of the 4-whorled glassy turbinated embryo-shell. *Whorls* 7 besides those of the embryo-shell; they are slightly shouldered below the suture, between which shoulder and the suture they are slightly hunchy; the last is rather small and slightly flattened. *Suture* not sunken, linear, undulated. *Mouth* small, narrow, oval, pointed at both ends, not expanded, exactly half of the shell in length. *Canal* rather narrow, short, turned back and to the left behind the pillar. *Outer lip* very slightly curved, not patulous, with a thin but strong straight edge, strengthened externally by a strong varix-like, somewhat remote rib, and internally by a strongish pad on which project 6 stumpy, somewhat elongated teeth. *Inner lip* flat, subpatulous, extremely thin, but with a very slight straight edge, which becomes a little stronger towards the point of the pillar; there a very small furrow appears behind the lip just where it takes a slight twist; at its upper end, just before it is joined by the outer lip, a feeble tubercle occurs, helping to define an indistinct gutter-like sinus, which does not cut the outer lip-edge. *Operculum* small, narrow, slightly curved, ruddy chocolate in colour; the *apex* is small and lies, when extruded, towards the

animal's head, when retracted it points towards the canal.—L. 0·8. B. 0·34.

Not common. Madeira, 50 fms.; Labra; Punta de São Lourenço (*Lowe*, *Johnson*, *Watson*).

This is the species which McAndrew gives at p. 40 of his Report as living on the "rocks" of the "shore;" "rare, species obtained in Canaries;" see also *l. c.* p. 32, where he says of it "rare—white." There are unnamed specimens of the species in his collection both at Cambridge and in the British Museum. On the shore-rocks I certainly never found it. Mr. Johnson's one young specimen came from a deepish-water coral, and Mr. Lowe's were dredged in Labra from a depth of some fathoms: but one or two of them are occupied by hermit-crabs, whose presence seems to indicate shallow water.

This species most nearly resembles *T. fusulus*, Broc., but it is narrower, flatter, with a narrower mouth; the sculpture is very markedly different. It has some likeness to *Murex cristatus*, Broc., and very worn specimens may be easily confounded, but the two species are unmistakably different. I feel by no means sure that this is not *M. productus*, Bellardi, Moll. Terr. terz. Piemonte, pt. i. p. 99, vii. 6; but his description is very vague, his measurements suggest a larger and narrower shell, and no specimen is available.

Fam. CERITHIIDÆ.

Gen. BITTIUM, *Leach*.

13. BITTIUM DEPAUPERATUM, n. sp.

Shell: a tall narrow cone with a contracted and produced base, barely translucent, slightly glossy, of a uniform pale yellow colour, occasionally palely brown banded. *Sculpture*: there are weak spiral threads, of which, on the body-whorl, five lie above the periphery and four on the base; these last are not cross-hatched but simple; the furrows which part these ridges are shallow and narrow; the number of the ridges and furrows is fewer on the earlier whorls, on the 2nd whorl they are only two; the threads are studded with rather blunt round tubercles which run in continuous and somewhat diagonal lines across the whorls—about 20 of these lines are on the last whorl; parallel to these cross-lines the whole shell-surface is feebly and microscopically undulated. *Colour* yellowish white, with occasionally a palish

ruddy-brown band on the lower two spiral threads. *Spire* fine and regular with very straight outlines—the extreme tip though small ends somewhat abruptly and flatly. *Whorls* 10, flat on the side, of very regular increase. *Suture* neither broad nor deep, but well marked—from the distinct though small contraction of the lower part of the superior whorl. *Mouth* small, oval, angulated above, and having a small shallow gutter at the point of the pillar. *Outer lip* flatly and regularly arched; the tubercles of the exterior sculpture very slightly and indeed rarely affect the inner surface. *Inner lip* thin but distinct, turned back and appressed on the pillar, where it is perpendicular with a slight twist resulting in a small tuberosity in front at the upper edge of the gutter.—L. 0·24. B. 0·08.

This is a much slimmer form than *B. reticulatum*, da Costa, with also a blunter apex; slimmer, too, than *Bittium incile*, Wats., and with much straighter contours and narrower base, and with smaller tubercles on the more numerous spirals. The species has a far-off but yet distinct suggestion of a *Cerithiella*. Very rarely a feeble varix appears on the last whorl.

This species I found abundantly on the south coast of Madeira and at Porto Santo, but it does not seem to have presented itself to other collectors.

14. Bittium incile, n. sp. (Figs. 14 & 14 *a*.)

Shell a tall narrow cone, but somewhat coarse both in sculpture and in its proportions; its contour-lines are very slightly curved, and from the periphery the base contracts slowly; its whorls are glossy, strongly defined, and almost turreted. *Sculpture*: the bluntly rounded apical whorl is microscopically and very faintly spiralled and longitudinally marked; the three following whorls have 2 and the succeeding four whorls 3 strong spiral ridges; on the base below the periphery there are 3 of these ridges, the last forming the bulge of the column; none are varicose, they are all strong but not very projecting, the appearance of prominence which on the spire they present being largely due to their being set with coarse rounded tubercles some 16 on each ridge, arranged in very regular longitudinal lines across the whorls; the longitudinal grooves which part them are broader but hardly so deep as those which separate the spiral ridges; the whole surface of the shell is microscopically but roughly fretted with sharpish longitudinal and ruder spiral lines; on the base

below the tubercles lies a small plain encircling thread, with a small narrow groove, within which lies a stronger ridge, these two ridges and the furrow between them are pale in colour, sometimes speckled; within the last of these ridges is a strong furrow, and then the strong ridge forming the twisted columella; this ridge and the furrow beyond it are stained deep chestnut. *Colour* varies from dark brown to ruddy chestnut, with a whitish band round the top of each whorl occupying the highest and extending sometimes to the 2nd spiral ridge, with an occasional intrusion to the ridge-tubercles here and there. Rarely the shell, though quite fresh, is pure dead white. *Spire* rather stumpy for the genus; the apex, though small, is not drawn out, and ends in a small, rounded, half-immersed tip. *Whorls* 9 to 9½, rarely 10, nearly flat on the side, of slow and very regular increase; relatively to the axis of the spire the longitudinal ridges run a little transversely. *Suture* very strongly marked, but its in-girdling appearance is due, not so much to its depth and breadth, as to the way in which the succeeding whorl projects below it. *Mouth* irregularly rhomboidal, with a small gutter rather than a notch at the point of the pillar. *Outer lip* straight and sharp, very slightly indented on the base, where it sweeps round with a semicircular curve to the point of the pillar, which leans away from it diverging slightly from the line of the axis. *Inner lip* has on the pillar a thin but well-marked projecting edge, which thins across the body but recovers its strength at the upper corner near the outer lip. *Operculum* small, elliptical, thinnish, paucispiral, with a central nucleus; the outer surface is closely scored with fine, curved, radiating lines densely crossed by a minutely microscopic tissue whose lines show the curves of growth.—L. 0·22. B. 0·075.

Madeira, Porto Santo, Selvagens, Grand Canary.

This species is found very abundantly. Mr. McAndrew, however, does not refer to it, nor did I find it in other collections. It is the same as a species sent to me from the Mediterranean as *B. lacteum*, Phil., but which is, I think, distinct from that species; the longitudinal spiral and basal threads are the same in number, but in *B. incile* the apex is smaller and more sunken, being neither so much produced nor so scalar as in that other; the contour-lines of the shell, too, are distinctly convex, not straight; the last whorl is more contracted, while the base is attenuated and rounded, not square.

Fam. CÆCIDÆ.

Gen. CÆCUM, *Flem.*

15. CÆCUM ATLANTIDIS, n. sp.

Shell very small, thin, transparent, of a dull glossy white, a good deal bent, subannulated. *Sculpture*: there are towards the tip a few sparse, somewhat feeble, but rather sharply topped, encompassing rings, which die out on the concave curve of the shell; one or two similar but feebler rings appear near the mouth; on the intermediate space undulations rather than rings are traceable; the whole surface is marked by faint lines of growth, and excessively minute, sharp, densely crowded microscopic longitudinal striæ. The *apex* is closed by a flat somewhat impressed plate, from the forward side of which projects a short, blunt, laterally compressed triangular plug. The *mouth*, which is circular, is neither contracted nor patulous. *Operculum* thin, impressed, brown, with circular lines of growth. —L. 0·085. B. 0·022.

C. vitreum, Carp., is larger than this species, and lacks its sculpture and circular rings, and has contraction of the lip. The plug in *C. atlantidis* is like that of *C. trachæa*, Mont., but the shell is much smaller than in that species; the circular rings are not close-set but are well parted; their tips are not flattened but sharp or rounded. *C. atlantidis*, without being rare, is certainly not common, and was not found in the collections of Lowe, McAndrew, or Johnson. I got it only at Porto Santo. For the beautiful figure of this species I am indebted to the Marquis de Folin, who was kind enough to draw it for me.

Fam. NATICIDÆ.

Gen. NATICA, *Adans.*

16. NATICA (NACCA) FURVA, n. sp.

Shell white, with two dark smoky bands which are sometimes absent but sometimes occupy nearly the whole shell, which is pretty strong, depressedly conical, with a small but a little raised spire and rounded whorls; the last of these is large, with an open mouth; a continuous white porcellanous pad fills the upper part of the mouth and nearly chokes the umbilicus. *Sculpture—Longitudinals* none, but lines of growth which,

however, from the suture a good way downwards present themselves as well-defined rounded curved riblets parted by narrower but open furrows; these riblets cease rather suddenly and pass into very faint lines of growth. *Spirals* none. *Colour* porcellanous white, somewhat translucent except round the whorls below the suture; below this dead-white band lies a broadish smoky-brown band, which in the upper whorls encircles their base; in the body-whorl below this dark band a white band of about the same breadth occupies the periphery; below it on the base is a slightly narrower dark band; the whole base round the umbilicus is white, but there is often a rusty tinge in the umbilicus and on the edge of the umbilical pad; there are colour-variations from uniform pure white to dark brown, with a pale base, but the spire has always a dark tinge. *Epidermis*: there are traces of a hard, corneous, yellowish-brown integument. *Spire* unusually small, but well-exserted and with a minute prominent dark tip. *Whorls* $4\frac{1}{2}$, not in the least angulated or gibbous; those of the spire are unusually small; the body-whorl is large, and gives breadth to the shell in spite of being longitudinally and obliquely drawn out. *Suture* scarcely oblique, linear. *Mouth* semi-oval, open, long rather than large, the whole plane of its edge retreats extremely from above to the base; its height is nearly four-fifths of the whole height of the shell. *Outer lip* thin, well arched, retreating to the base, but from that point advancing slightly to the pillar. *Inner lip* oblique, nearly straight, thickened by a broad white porcellanous pad which fills the whole upper corner of the mouth, projecting there in a blunt, low, rounded prominence; the face of this pad projects bluntly all the way to the point of the pillar, it crosses the body with a straight well-defined edge whose direction is oblique; where it quits the body to join the rust-stained umbilical pillar-pad it is more or less deeply cut by the umbilical furrow which sometimes feebly, sometimes very strongly, twists out round the pillar, circumscribing it markedly but failing to cut in on the edge of the inner lip, which here to the point of the pillar is shortly reverted and slightly thickened. *Umbilicus* is sometimes a mere depression, but normally is a strong but rather narrow furrow coiling round the pillar and deeply penetrating the middle of the shell. *Operculum* calcareous, pure white, pretty strong, lustrous, fairly flat, but slightly padded in the nuclear region, from which a very slight rounded swelling curves with

the progress of growth; outside of this swelling lies a small shallow, open, but well-defined furrow, beyond which on the extreme edge of the operculum rises a single small, simple, narrow flange.—H. 0·47. B. 0·42.

The marked features of this species are the curved radiating riblets below the suture, the two smoky bands, the small dark prominent spire, the sharp apex, and the entire absence of the slightest trace of the reddish-brown flammulations some trace of which is always visible in *N. variabilis*, Récl., and *N. Dillwynii*, Payr. It is very common from the whole coast of Madeira and of Porto Santo, from 10 to 50 fms. I found it sparingly represented in the collections of Mr. Lowe and of Mr. Johnsón.

Fam. Scalariidæ.

Gen. Scalaria, *Lam.*

17. Scalaria rhips, n. sp. (ῥίψ, wicker-work.)

Shell small, conical, rather strongly but sharply ribbed and spiralled; carinated round the smooth and flattened base, a high narrow spire, depressed whorls which are rounded at their profile, an impressed suture; it is dull, somewhat ruddy, and has a small, conical, fine-tipped, pale chestnut-coloured, smooth embryonic apex. *Sculpture—Longitudinals*: there are on the 5th (*i. e.* last) whorl 22 prominent but narrow palish ribs cut off at the basal carina, separated by smooth surfaces of double their breadth; they follow closely the plane of the axis, and slowly diminish in number all the way up the spire. *Spirals*: there are on the body-whorl 5 prominent spirals very similar to the longitudinals, beneath which they pass without forming knots but throwing out these others somewhat sharply; of these spirals the two at the periphery are stronger than the others and slightly more distant from each other; the wide flattened base (whose edge projects slightly beyond the curve of the last whorl, and thus forms a carina) is microscopically scored with curved radiating lines and with much ruder but fainter spiral threads. *Colour* somewhat ruddy, with rather paler ribs and base, the pillar being almost white, while the apex is glossy chestnut. *Spire* high and narrow, with barely convex profile-lines. *Whorls* $5\frac{1}{4}$ exclusive of the apex; they are rather short, with a rounded profile. *Suture* strong and deep, very little oblique. *Apex* a very beautiful glossy pale chestnut little cone of 4 whorls, which

are microscopically marked with spiral and longitudinal striæ; the extreme tip is slightly immersed, small, bluntly rounded; the basal whorl of these four is slightly tumid, with a minute, flatly spreading edge, from within which the regular growth of the shell begins abruptly. *Mouth* slightly elliptical. *Lip* not fully developed.—H. 0·14. B. 0·06.

This is a singularly beautiful little shell; among the *Scalarias* of the Italian tertiaries there are some species that faintly recall the Madeiran form; among living species *S. decussata*, Kien. (not Pease), alone has some slight features of resemblance, but they are very slight. The sculpture is like wicker-work, and hence the name of the species. I got only one young specimen from 50 fms. in Funchal Bay.

18. Scalaria aspera, n. sp.

Shell ruddy, small, high and narrowly conical, roughly fretted on the whole surface, strongly ribbed, tuberculately carinated within the rounded base, and with an oblique, impressed, and crenulated suture. *Sculpture—Longitudinals*: there are on each whorl up to the very top 10 or 11 strong, narrowish, rounded not outspread ribs, running continuously with a slight trend to the right from whorl to whorl down the spire, on either side of which is one stronger than the rest, that on the outer lip being peculiarly prominent; the interspaces are rounded and slope up the sides of the ribs; towards the top of the spire they are nearly crowded out by the ribs. *Spirals*: the whole surface of the shell is covered by irregular, unequal, flattish rounded threads, of which about 30 of the larger can be counted on the body-whorl; but there are others smaller past counting; all these spirals, both larger and smaller, are sharply densely crenellated by tooling produced by minute tubercles which often run over into fine longitudinal threads; well within the base round the pillar runs a very coarse string-keel which towards the lip is strongly continuous and rises on the ribs in low swoln rounded tubercles. *Colour* a dull ruddy hue as if dusted over with a palish powder. *Spire* high and narrow, with very straight profile-lines. *Whorls* 7, exclusive of the embryonic apex which is broken off; they are small but not short, slightly hunchy beneath the suture, but very slightly convex below. *Suture* oblique, impressed, and rather strongly crenulated. *Mouth* circular, but a little flattened on the upper inner side. *Lip* a minute sharp, not expanded

flange projects round the edge of the mouth, attached as a shelf across the body; it projects minutely down the pillar, but leaves no chink behind it.—L. 0·2. B. 0·08.

From 50 fms., Funchal Bay.

This species has so much character, that though I found only one possibly young and not quite perfect specimen, I do not think it will ever be difficult to recognize. It is more like *S. tortilis*, Wats., 'Challenger' Gaster. p. 139, ix. 1, than any other I know; but that species has a shallower and less oblique suture with flatter-sided whorls, and the whole sculpture, but especially the basal keel, is totally different. *S. funiculata*, Wats. (*l. c.* p. 141, ix. 4), is still more divergent. It is certainly not the *S. crenulata*, Linn., of the Canaries, nor the *S. Hotessieriana*, d'Orb., of Cuba. It belongs to the very marked and curious group which, besides those referred to here, includes the *S. longissima*, Seguenza, the *S. torulosa*, Broc., and several others given by Sacco from the Italian tertiaries, and by Deshayes from the Paris basin.

19. Scalaria Fischeri, n. sp.

Shell small, delicate, translucent, with short, rounded, depressed whorls, a scalar spire whose whorls are each rather more contracted at the bottom than at the top, fine close-set spurred ribs and very distinct spirals, a strongly impressed, not very oblique suture, and a small base. *Sculpture—Longitudinals*: 23 or 24 thin projecting riblets, which crowd the surface, and from each of which close to the suture rises a small tooth, often broken off. *Spirals*: of these some 17 to 20 can be counted on the 2nd last whorl just above the corner of the mouth; they are rounded, well raised, can be traced as they cross the riblets, and are, like the whole surface of the shell, fretted with minute longitudinal scratches. *Colour* translucent white. *Spire* high and narrow. *Whorls* 7, exclusive of the embryonic tip; they are short, with a rounded profile, but lie like somewhat oblique slabs from the depth and straightness of the suture and the expansion of each whorl below the suture in consequence of the minute projection there of the tooth which crowns each rib. *Suture* deep, strongly marked by the flat shelf below it on the top of the succeeding whorl; it runs somewhat obliquely but in a very straight line across the shell. *Apex* has a peculiar almost metallic sheen, is a very perfect, rather high, fine-pointed cone,

which, as set on the spire, slightly diverges from the axis of the shell; it consists of 4 full whorls, flat-sided, glossy, faintly striated longitudinally, which are parted by a barely impressed, slightly chestnut-tinged suture. *Mouth* very slightly elliptical in the axial line, the pillar being little curved. *Lip* patulous all round and flat-edged, except just where it crosses the body-whorl, and is there attached so as to leave no umbilical chink whatever. —H. 0·25. B. 0·09.

My specimens are nearly all young, but the size was measured from the juxtaposition of 2 or 3 larger, well-preserved fragments. The apex, the suture, the shape of the whorls, the stumpier form, the crowded longitudinals bespurred close to the suture, the crisper spirals, and the absence of any approach to an umbilicus, markedly differentiate this species from *S. Smithii*, which superficially it seems very like.

Not rare, from deepish water along the S. coast from Funchal to Punta de São Lourenço; other collectors did not meet with it. I have named the species in remembrance of my much lamented friend Dr. Fischer, of the Jardin des Plantes, Paris.

20. Scalaria Smithii, n. sp.

Shell small, with short, rounded, slightly depressed whorls, a spire which is a little scalar, fine translucent mucronate ribs, very delicate spiral threads, a slightly impressed little-oblique suture, and a rounded umbilicated base. *Sculpture—Longitudinals*: on the lower whorls there are about 20 fine sharply projecting translucent riblets, which run in a slightly oblique discontinuous line from whorl to whorl down the spire, on the earlier whorls they are somewhat fewer in number; on each riblet, slightly above the periphery, there projects a small nearly right-angled tooth—very often broken off. *Spirals*: there are about 15 to 20 very fine rounded little raised threads, which tend to become fainter about the periphery of each whorl. *Colour* saccharine white. *Spire* high and narrow. *Whorls* 6 (exclusive of those of the apex); they are rather short and tumid, markedly broader below than above, and are of very regular increase. *Suture* fairly impressed and rather oblique. *Apex*: 3 complete rounded whorls form a small high regular blunt cone on a small base set on a little to one side of the axis of the spire; these whorls are microscopically barred longitudinally. *Mouth* almost quite round, not small. *Lip* sharp-edged, not patulous,

level-fronted, slightly detached (in the full-grown shell) from the body, and leaving behind it a small distinct funnel-shaped umbilicus.—H. 0·17. B. 0·07.

This species very much resembles *S. Fischeri*, but is distinct. It is a larger form, the spire is in proportion broader, the whorls are rounder and less depressed; the apical whorls are 3 not 4, they are smaller and the way in which they are set on the top of the spire is peculiar; the spiral threads are sparser, flatter, finer, and more rounded, and at the periphery somewhat fainter; the longitudinal ribs are fewer and sparser; the minute tooth on these, when present, occurs lower on the whorl (that is, nearer the periphery), while in *S. Fischeri* it comes very near the suture; the base of the embryonic apex is much smaller. I have named the species after Mr. E. A. Smith, of the British Museum, whom often, and always profitably, I have had occasion to consult. Specimens, several in number, were mixed up with shells of *S. Fischeri* I had got from Funchal and Punta de São Lourenço and also from Porto Santo, Madeira.

Gen. Aclis, *Lov.*

21. Aclis vitrea, n. sp.

Shell thin, hyaline, glossy, tall and narrow. *Sculpture*: there are very faint unequal lines of growth; a very feeble spiral angulation is sometimes traceable round the base of the whorl. *Colour* glossy, transparent white. *Spire* high, with very regular narrow outline and a bluntish rounded half-immersed tip. *Whorls* 7; their curve is a very regular flattened arch. *Suture* shallow, oblique. *Mouth* a full round oval, small. *Outer lip* thin, prominent, but toward the body it is drawn back almost into a sinus, somewhat expanding on the base. *Inner lip* thin, sharp, and patulous; its connection across the base with the outer lip is long and very filmy. *Umbilicus* a small funnel-shaped shallow depression.—L. 0·08. B. 0·029.

This species is a good deal like *A. Walleri*, Jeffr., but is much smaller, with 7 instead of 10 to 11 whorls; the spire is much broader, the tip much larger and coarser in proportion to size, the whorls are longer, more regularly rounded, much less expanded round the axis, and the contour of each is more compressed, the suture is more oblique, the mouth smaller, lip open rounder.

This species is abundant in deep water from Funchal to Punta

de São Lourenço, and from Porto Santo. The animal is dark green in colour. I have met with it nowhere but in my own dredgings.

The shell somewhat resembles that of *Aclis Gulsonæ*, Jeffr., but is very much smaller, the spire is much more contracted and ends in a minute knob of a point, the outer lip is inflected instead of being prominent and expanding, the suture is much deeper, and the whorls are more prominent and rounded.

22. Aclis trilineata, n. sp.

Shell thinnish, semitransparent, rather glossy, longish, narrow with squarish outlines. *Sculpture*: there are on each whorl 3 very strong rounded but slightly crested threads, absent on the embryonic tip, faint on the two succeeding whorls but well-marked on all the others—no others appear on the base; the 1st, which is the strongest, lies a little remote from the suture and forms for the whorl a well-marked shoulder; the 2nd, though helped by the bulge of the whorl, is barely more prominent than the first; the 3rd is slightly feebler than the others, and lies near but quite clear of the suture: besides these there are faint close-set microscopic striations and vaguer traces of longitudinal markings; the furrows between the threads are shallow and rounded. *Colour* white and semitransparent. *Spire* high and narrow, ending a little abruptly in a small rounded, not prominent tip. *Whorls* $6\frac{1}{2}$. From the suture there is a downward sloping shoulder to the first thread, from which the very straight contour-line runs down parallel to the axis, and with scarcely any contraction into the suture below. *Suture* broad, open, and shallow, rather oblique. *Mouth* oval, rather large. *Outer lip* thin, with a free convex sweep. *Inner lip* thin, sharp, and prominent, with a well-rounded curve it spreads very thinly across the body. *Umbilicus* a shallow, small, funnel-shaped depression.—L. 0·08. B. 0·03.

Of this species I got only 5 specimens (and of these but one full-grown) in deep water from the east end of the island. The shell slightly resembles *A. ascaris*, Mont., but is smaller, less delicate in the whorls, spire, and tip, and is different in sculpture.

23. Aclis tricarinata, n. sp.

Shell strong, rather stumpy, semitransparent, and somewhat glossy. *Sculpture*: excessively strong spiral keels project from

each whorl, from below the embryonic whorl two of these appear on each succeeding whorl, weaker than these a third one lies just above the suture and runs out on the last whorl at the corner of the mouth nearly as strong as the other two: on the base a similar but weaker keel encircles the pillar. These keels are parted by a flat shallow furrow, which is rather over ·001 in. in width, and which is scored across by pretty close-set distinct but not strong round-topped longitudinal threads, which again are scored by microscopic spiral striæ; these striæ, but hardly the longitudinal threads, are visible on the top of the spiral keels. *Colour* white, glossy, but hardly brilliant. *Spire* high and narrow, with a blunt, globular, regular, one-sided, hyaline, glossy tip, consisting of one whorl on which some very faint longitudinal striæ are doubtfully traceable. *Whorls* 6, with a contour very much angulated by the spiral keels and the broad sunken suture. *Suture* is wide, deep, and rather oblique. *Mouth* obovate, rather large. *Outer lip* has a sweep which in itself regular is much disturbed, especially on the base, by the spiral keels and furrows, these give the thin lip-edge an unfinished appearance. *Inner lip* somewhat irregular, from the forward tip to the umbilicus it is patulous and slightly curved; where it strikes the base the curve is obtusely and roundly angulated; across the body the lip runs in an oblique straight line with a projecting strongish edge till past the umbilicus, when it lies close back on the body and though thinner continues till it joins the outer lip. *Umbilicus* is a deep narrow chink.—L. 0·08. B. 0·035.

This species I found sparingly (some 25 specimens) at the Gorgulho shore, and in deeper water at Punta de São Lourenço. It is the unnamed "rare" species which McAndrew gives (Geog. Distrib. p. 32) as dredged by him in 12 fms. at Orotava, Tenerife, and specimens of which are in his collection. At first sight the shell is startlingly like the *Hydrobia bicarinata*, des Moulins, from the South of France, but the differences are very marked.

Fam. Eulimidæ.

Gen. Eulima, *Risso.*

24. Eulima fulva, n. sp.

Shell shining but not brilliant, very small, straight, with a blunt rounded tip, slightly convex whorls, and a slightly produced somewhat truncate base. *Sculpture*: lines of growth are just recog-

nizable under the microscope, but the surface is not very glossy. *Colour* a rich deep chestnut, with a pale yellowish narrow band round the base of each whorl and occupying the outer lip and extreme base of the shell. *Spire* narrow, with straight outlines, the whorls being barely rounded. *Apex* small, but very bluntly rounded, and its two sides are scarcely unequal. *Whorls* 6; of regular and slow increase, barely rounded. *Suture* slightly oblique and a little impressed. *Mouth* rather short and somewhat broad. *Outer lip* has the edge slightly sinused near the body and convex to the base—in direction it runs straight; on the broadish base it is fairly patulous and in its curve regular. *Inner lip* a longish but very little convex curve across the body to the point of the short pillar; it is a little thickened, but not in the least expanded.—H. 0·067. B. 0·027.

In deep water at the east end of the island—not rare.

This species is very like *E. Jeffreysiana*, Brus., but is smaller and narrower, with fewer, less rounded whorls, a much blunter spire, a shorter base, and a much shorter and rounder mouth; its colour also is a much deeper richer chestnut.

It is absent in all the other collections I have seen.

25. Eulima sordida, n. sp.

Shell shining, very small, straight, with a very narrow spire, very blunt tip, barely convex whorls, very blunt base, and oval mouth. *Sculpture* very doubtful, if any. *Colour* a sordid yellow. *Spire* narrow and straight. *Apex* very small, but blunt and round; its two sides are very equal. *Whorls* 7, of very regular and slow increase, almost perfectly flat on the sides. *Suture* scarcely impressed, but visible from the transparency of the shell—hardly oblique. *Mouth* very small, oval, but narrow pointed at the top. *Outer lip*: its edge advances a little from where it leaves the body, but the whole curve of the mouth is very regular. *Inner lip* is very slightly patulous on the pillar with a minute chink behind it, and it is very feebly angulated where it joins the body.—H. 0·066. B. 0·024.

Punta de São Lourenço—rare. Found only by myself.

This species is very much less like *E. Jeffreysiana*, Brus., than is *E. fulva*. From the latter it differs in being smaller with nearly a whole whorl more, it is narrower, the mouth is smaller and rounder, the base more truncate, the whorls are less rounded, the suture less impressed, the apex is smaller and rounder, and

even in bleached specimens the paler and whiter colour is well marked.

26. Eulima badia, n. sp.

Shell small, brilliant, dark brown, conical, with straight contour-lines, a smallish mouth, a rather attenuated base, and a very small tip. *Sculpture*: there are minute hair-like lines of growth with some very faint superficial and irregular spirals. *Colour* a deep rich chestnut, darker than in *E. fulva*; the extreme point of the base is pale and transparent. *Spire* high and narrow, conical, with straight contour-lines which do not perfectly correspond on the two sides. *Apex* exceedingly small and sharp, but round withal. *Whorls* 9, of exceedingly slow and regular increase and just perceptibly rounded in outline, the first three being markedly more so than the others; the last one is small, but that is from being short rather than narrow. *Mouth* oval, rather small, and not much pointed above. *Outer lip* thin, well arched, with an edge retreating well above and advancing not very much at the periphery. *Inner lip* very faint on the body, thickened and somewhat expanded on the pillar, behind which is a slight umbilicus; at the base the pillar is very slightly truncated.—H. 0·1. B. 0·044.

Very rare. The few known specimens I got at Punta de São Lourenço.

The sharp apex and larger size differentiate this species markedly from *E. fulva*, which it resembles in colour. In general appearance it is like *E. Jeffreysiana*, Brus., but the apex is distinctly sharper, the contour-lines of spire are straighter, the whorls are shorter, of slower increase, and of more convex outline; in shells of the same length, *E. Jeffreysiana* has one whorl fewer. I have no doubt some one will say they are the same, but that will none the less be a mistake. Than the young of *E. stenostoma*, Jeffr., this is much finer in the apex and is broader in its proportions; like *E. gracilis*, F. & H., in apex, it is of a stumpier form. Than *E. Philippii*, Weink., this is slimmer, the spire is not bent, the base is more elongated, the periphery is not carinated. With the young of larger species it is needless to compare so slim and small a form; a careful comparison fully confirms one's first impression of diversity.

27. Eulima rhaphium, n. sp. (ῥάφιον, a small needle.)

Shell very small, very narrow throughout its whole length

with a very small tip, an attenuated base, and a small narrow oval mouth. *Sculpture* none, the surface being glassy. *Colour* hyaline white. *Spire* exceedingly high and narrow; the contour-line on the right is quite straight, that on the left slightly curved, but both are perfectly uninterrupted by any swell of the whorls or contraction of the suture. *Apex* minute and symmetrically rounded. *Whorls* 11, of very slow and regular increase, the last is both short and narrow but not contracted. *Mouth* small, narrow, oval, pointed above. *Outer lip* thin, straight, its edge hardly retreats above or advances at the periphery. *Inner lip* has a slightly thickened edge and curves very regularly across the body and down the pillar, with hardly the slightest furrow behind it; it has no truncation at the base.—H. 0·11. B. 0·03.

One specimen I got from deep water in Funchal Bay.

This is a very much slimmer form with a finer apex and narrower spire than any of the other Madeiran species, none of which in their youngest state approach it in these respects; even the small form of *E. Philippii*, Weink., of the same length is much broader, has fewer whorls, a much larger base, rounder mouth, and more projecting outer lip. *E. psila*, Wats., from the W. Indies, resembles it most, but is a larger shell with a coarser apex.

28. Eulima trunca, n. sp.

Shell conic-oblong, ivory-white, strong, straight in all its lines, with a broad short base and sharp tip. *Sculpture* none, the whole surface being brilliantly glossy; but a feeble flattened varix appears on each whorl and runs interruptedly up the spire. *Colour* ivory-white, but very slightly pellucid. *Spire* high and conical, with very straight contour-lines, the whorls being just barely rounded in outline. *Apex* very small and sharp, but very slightly impressed. *Whorls* 9, of very slow and regular increase, the upper ones just barely, the lower not at all rounded in outline, the last is short with a truncated well-rounded base. *Suture* hardly oblique, slightly abruptly but distinctly impressed. *Mouth* fairly oval, but with its curve on the left-hand side a little constricted, shortly pointed above. *Outer lip* thick, with a rounded edge which has a feeble and wide sinus above and a slight forward curve about the periphery of the shell. *Inner lip* a good deal thickened and well defined

across the body, but still more on the pillar, at the point of which is a very shallow sinus.—H. 0·2. B. 0·1.

Found by Mr. Lowe in dredging near Punta de São Lourenço, near which I also got it as well as on the Gorgulho shore to the west of Funchal.

This species slightly resembles *E. paivana*, W., but is larger, with a sharper apex, a more abrupt base, straighter contour-lines, flatter whorls, a shallower but more sharply impressed suture. I have examined *E. Stalioi*, Brus., with which Jeffreys (P. Z. S. 1884, p. 368, xxviii. 3, 3*a*), simply followed by Tryon (Manual, VIII. p. 275, lxix. 53), on examination of my specimens, identified this shell. The Madeiran species is certainly not that figured by Jeffreys and copied by Tryon; but Brusina, I believe, questions the correctness of Jeffreys's identification, and the figure with a strangely bent spire as given in the P. Z. S. (*loc. sup. cit.*) is obviously not the same as Brusina's figure in Journ. de Conch. 1877, and described in the same journal for 1869, p. 242. The *E. glabella* of Searles Wood is a much (three times) larger shell, and has, like Brusina's species, a more obtuse apex than *E. trunca* of Madeira. *E. microstoma*, Brus., and *E. intermedia*, Cantr., are both much slimmer forms, and especially in the spire narrower. The varix in the Madeiran species resembles that of *E. polita*, L., a very much larger species with a much narrower spire.

29. Eulima inconspicua, n. sp.

Shell small, narrow, but less contracted in the spire than most species, thin, translucent, straight, with a produced base, a shortish narrowly oval mouth, and a small tip. *Sculpture* none, but the surface is dull. *Colour* translucent white. *Spire* high, not bent, but the contour-lines are slightly convex. *Apex* very small and sharp. *Whorls* 10, barely convex, of regular but not very slow increase. *Suture* very slight and scarcely at all oblique. *Mouth* smallish, oval, narrow, pointed above. *Outer lip* thin, sharp, rather straight in its direction, well rounded and patulous on the base; near the body it retreats, forming a marked sinus. *Inner lip* slightly concave, on the body almost imperceptible but a little thickened and reverted on the pillar, where its well-defined edge is marked by a slight chink; at the point of the pillar there is a slight truncation.—L. 0·13. B. 0·04.

Very rare. The only specimens of which I know were got at Punta de São Lourenço.

Compared with *E. intermedia*, Cantr., this, besides being smaller, is narrower, has a longer base, a more slowly contracted spire, and a slightly larger apex. *E. microstoma*, Brus., has a shorter rounder mouth with a more truncate and slightly broader base. The *E. glabra*, Jeffr. (Lightn. & Porc., P. Z. S. 1884, p. 367, xxviii. 2), is slightly like this species, but is a much larger and stronger shell, with a broader coarser apex and a larger mouth.

Fam. PYRAMIDELLIDÆ.

Gen. ODOSTOMIA, *Flem.*

30. ODOSTOMIA OMPHALOESSA, n. sp. (*ὀμφαλόεσσα*, umbilicated.) *Shell* small, conical, translucent, dullish, with a somewhat swoln umbilicated body-whorl, a shortish spire, and a small abruptly truncated tip, across which the sinistral embryonic shell lies on its side. *Sculpture* none but very faint lines of growth: there is no keel at the periphery even in young shells. *Colour* translucent, almost transparent, with a slight ruddy tinge, so that the general appearance is a little horny. *Spire* short, small, of few whorls; conical, with a small truncated tip crowned by the sinistral embryonic shell which lies on its side across it. *Whorls* $4\frac{1}{2}$ exclusive of the embryonic tip, fairly curved in contour, and not compressed; the last in particular is large and a little tumid, with freely curved outlines: it makes up $\frac{5}{8}$ of the shell's height. *Suture* is strongly marked, being neither shallow nor narrow: its line is very little oblique. *Mouth* short and round, the length being to the breadth very nearly as 5 to 4, very little pointed above. *Outer lip* sweeps with a very free curve all round, is not inflected above, and is barely patulous below. *Inner lip* is very thin and barely convex on the body, which it quits rather early (breaking soon but not immediately into a strong but short tooth), very slightly reflected, not straightened down the pillar, at the point of which it is barely patulous and is not angulated. *Umbilicus* wide and open, but soon contracted. —H. 0·07. B. 0·036.

Rather common, but absent in other collections than my own.

This species is rather like a small *O. acuta*, Jeffr., but is less conical, has the whorls, especially the last, more tumid and rounded, with no keel round the base nor on the periphery even

in the younger shells, has the suture less oblique and deeper, the mouth is rounder, the pillar is not straightened nor the lip flattened and produced at the base, the umbilicus is freer, even a little larger, and the pillar-tooth lies a little higher on the body-whorl.

31. ODOSTOMIA (TURBONILLA) UNDATA, n. sp.

Shell cylindrical, strong, dull, pure white. *Sculpture—Longitudinals* strong, rounded, slightly oblique ribs, of which there are 16 or 17 on the penultimate whorl, but they are disproportionately numerous on the last whorl, where they become narrower and more crowded near the lip-edge; on the base they are feebly present, they are separated by strongish rounded furrows; they are traceable up to the tip, but not on the embryonic whorl; on the later whorls one or two are varicose. *Spirals*: there are no definite threads, but there is a very faint suggestion of close superficial microscopic puckering extending to the whole surface, but very obscure. *Colour* a dull glossy deadish white. *Spire* high, less conical than usual, that is broader in the upper and narrower in the later whorls than most of the group. *Apex* abruptly and somewhat squarely cut off, the extreme tip being slightly immersed, leaving in profile a minute rounded dome. *Whorls* 6, very equally rounded and loosely twisted, the last is just $\frac{1}{2}$ the total length of the shell. *Suture* rather deep, but small and very little oblique. *Mouth* widely oval, bluntly pointed above, slightly patulous on the base, rather more than a fourth of the whole length. *Outer lip* not sharp, bent in but not sharply at its junction with the body-whorl just below the periphery; its whole curve is very regular. *Inner lip* as a mere glaze and very little obliquely it crosses the body, is scarcely angulated at the pillar, down which it runs with a very sharp but barely projecting edge, and only at the extreme point of the pillar (where it becomes faintly patulous and forms a slight angulation in curving to the right) does the lip palpably project. There is no umbilicus and no pillar-tooth.—H. 0·15. B. 0·05.

Extremely rare. Two specimens are all I found; they came from the Gorgulho shore.

At first sight this species is very like *O. clathrata*, Jeffr., with which Dr. Gwyn Jeffreys at first classed it, but afterwards revised his opinion. That species is more transparent, less of a dead white, is more conical, has smaller ribs with spiral striæ,

a smaller and more narrowed apex, and a more turned-over tip, the mouth is narrower, the pillar-edge more prominent, and there is an umbilical chink.

Fam. Pleurotomariidæ.

Gen. Schismope, *Jeffr.*

32. Schismope depressa, n. sp. (Figs. 32 *a*, 32 *b*, 32 *c*.)

Shell very small, hyaline white with a tinge of pale brown, obliquely depressed, flattened above, with a minute apex and linear suture, a large sub-circular mouth, and a large half-funnel shaped fissure for an umbilicus; its last whorl is carinated on its upper surface by the raised edges of the scar of the respiratory orifice. *Sculpture—Longitudinals*: there are on the earlier whorls close-set radiating riblets which are sometimes obsolete, and in all cases degenerate on the base and on the later whorls into mere threadlets widely parted; the whole surface is further scored by sharp radiating curved scratches. *Spirals*: nearly half of the last whorl is keeled (but not angulated) by the canal-ridge which rises well within the periphery, and leads to the narrow oblong respiratory orifice which is formed in the shell as it grows, and is plugged up at its posterior end as the shell-edge is pushed forward in growth; along the interior of the shell the edges of the disused canal project in a minute sharp-edged flange; on the outside from the front of the orifice on to the mouth-edge an irregular depression (visible within the mouth also) scars the shell-surface; the shell-substance shows no trace of this interruption in the earlier whorls, and the strong oblique downward bend of the last whorl only arises with the expansion of the last whorl and very shortly before the respiratory orifice claims a place. Above the keel the flat surface is scored by about ten fine threads and furrows which become fainter and sparser near the suture; below the carina the whole surface is similarly but more strongly and irregularly scored. *Spire* very much flattened, *apex* hardly raised. *Whorls* barely three, of sudden increase. *Suture* scarcely impressed. *Mouth* large, gibbous like a nearly-full moon, excessively oblique. *Outer lip* greatly descending, flat above, well rounded but scarcely patulous below, where at the pillar-point it forks and the outer edge of it sweeps round a little within the edge of the

umbilicus, and rejoins the pillar-lip at the corner of the mouth. *Inner lip* projects very slightly, is a little patulous, and leaves behind it only a broad umbilical fissure. Across the body it is hardly curved, and joins the outer lip almost at a right angle. —H. 0·025. B. 0·032. Mouth: H. 0·021; B. 0·017.

Common from Funchal eastward and at Porto Santo, deep water. It does not seem to have been observed by any one but myself.

If the shell be really nacreous, the layer of nacre must be so transparently thin as to give no opalescent reflection. The species is very like *S. tabulata*, Wats. ('Challenger' Gasterop. p. 117, viii. 7), but is very much smaller in all its dimensions, especially in height of spire; in spite, too, of superficial resemblances, it differs in sculpture, the riblets being here much fewer and feebler and more curved, the canal-keel and respiratory hole lie much nearer the suture, the spirals are feebler, the last whorl too is larger and not so much contabulated. It should be noted how deceptively different the adolescent is from the full-grown shell.

This is the shell a hasty identification of which from my specimens led Dr. Gwyn Jeffreys to quote *Scissurella costata*, d'Orb., for Madeira.

Fam. ERYCINIDÆ.

Gen. MONTACUTA, *Turt.*

33. MONTACUTA TRIANGULARIS, n. sp.

Shell triangularly round but not at all rhomboidal, somewhat tumid, strongish but almost transparent, bright but not brilliant. *Sculpture* fine, close-set, somewhat unequal concentric lines of growth. *Colour* clear white. *Epidermis*, none visible. *Margin* rotundly oval but for the upward and backward prominence of the beaks; the edges of the valves meet directly with very little expansion at coming together. *Beaks* small, rounded, sufficiently prominent to give a triangular aspect to the shell; they are somewhat nearer the back end of the shell, towards which but still more upward they slightly turn. *Hinge-line* broken into a right angle by the beak; the edge is long and very narrow in front, behind it is comparatively very short and broad. *Hinge-plate* has a deep triangular cleft from the interior of the shell to the beak; in the right valve on either side of this cleft there rises a solid little rounded tooth; in the left valve the cleft is

bordered by a remote longish narrow lamina which rises into a small rounded prominence. *Inside* glossy, with a suggestion of faint radiating lines in the inner substance of the shell.—L. 0·13. H. 0·09.

Rare; but found by Mr. Lowe and Mr. Johnson as well as myself. I dredged it both at Funchal and at Punta de São Lourenço. This species is much more triangular than *M. bidentata*, Mont., and much more oval than *M. striata*, Mont.

Fam. Cyprinidæ.

Gen. Coralliophaga, *de Blainv.*

34. Coralliophaga Johnsoni, n. sp.

Shell very irregularly rhomboidally oval, the straightish hinge-margin which runs out in front to a small bluntly rounded corner being vaguely parallel to the rounded lower margin, while the oblique straight but slightly incurved front line is in a way parallel to the easy sweep of the convex, almost semicircular curve of the posterior margin: the valves are tumid above and in front, but are a little compressed behind and below; they are in substance thin, subpellucid and fragile, with fine sharpish but unequal concentric lines of growth. *Colour* dirty yellowish white, with a chestnut tinge towards the beaks. *Epidermis* very thin, worn off except towards the hind margin, where it shows a tendency to slight irregular puckering. *Beaks* small, rounded, polished, pointing forwards, and bent in on the hinge-line so as to meet one another; they lie a little in front of the middle of the dorsal margin. *Margins*: they fit quite closely, and, where the lips are not inverted, meet one another in the face abruptly, except below where the shell is slightly flattened out. *Ligament* ruddy brown, thin but strong, prominent, short, ceasing abruptly at the beaks. *Hinge-line* straight, narrow. *Teeth*: there are three small rounded laminæ in each valve, forming a little shelf on the inner side of the hinge-margin; they are nearly parallel with the hinge-margin; the front one, which is a little hummocky, is the shortest; the second, which is directly under and behind the beak of the shell, is longer and more compressed; while the posterior one is somewhat vaguely spread out and cut up; in the left valve it is a little more developed than in the right, otherwise in the two valves the teeth are very much alike. *Inside* not nacreous, but doubtfully opalescent, only vaguely fretted, quite

smooth and shining, but not polished except on the *muscular scars*, of which the anterior, semilunar in form, is pushed up into the extreme front rounded corner of the shell, while the hinder one, also placed very high, is oval; the two are connected by a strongly marked but narrow ragged-edged pallial line, which below and behind retreats into a broad, very shallow sinus.—H. 0·55. B. 0·6.

Mr. J. Yate Johnson, whose name I have attached to this very interesting species, got the few specimens known of it in a mass of oysters and corals dredged up from over 30 fathoms off Funchal. On superficial examination I took it for *Modiolarca trapezina*, Lam.; but Mr. Edgar A. Smith kindly examined it for me, and he assures me it is a *Coralliophaga*, and distinct from any in the British Museum. The young shell scarcely shows the compressed posterior and the expansion below which characterize the adult.

Fam. Teredinidæ.

Teredo, *L.*

35. Teredo Dallii, n. sp.

Shell small, convex, solid, translucent, glossy internally and externally, scored by a very slight ridge and minute furrow from the beak to the point of the shell, and by a fine sharp line which curves across the surface from the beak to the front marginal angle, answering to a fine raised white rib in the interior. *Sculpture*: the front area is covered with low, rounded, fine (sometimes, but rarely, strongish) threads, the excessively minute but somewhat irregular microscopic serration of which is almost wholly confined to the upper edge, from which, however, it faintly extends to the lower side of the flat furrow above; where these threads abut upon the ends of the answering mid-area ridges their termination is sharply defined by a small but strongly marked furrow, which curves down with posteriorly convex sweep from the beak to the apex of the right angle at the margin where the front area and the central area meet. On the central area the ridges are stronger, are nearly contiguous, and are much more strongly and obliquely serrated, almost tubercled. In number they are usually about 20; but even in specimens of equal growth the number sometimes amounts to 30. Behind this mid-area is a shallow flat with a slight depression, sometimes a

furrow, across which the tails of the mid-area ridges spread somewhat rudely in concentric upward-facing curves; the back-edge of this is a very regular curve from the apex to the point, and which drops rather abruptly into a little shallow furrow, beyond which the thin flat concentrically-undulated posterior ear projects (somewhat as in *T. megotara*, Hanl.), placed rather low but still quite on the shoulder of the shell; a very shallow obtuse angle lies between this ear and the back margin of the posterior area. In the young shell this ear is generally somewhat obsolete; the ear-edge is not reverted. *Dorsal line* not much irregular. *Beaks* are like smallish round knobs from which, somewhat posteriorly, a minute cup-shaped process projects perpendicularly, while the *apophysis* springs from the same knob but a little farther back: it is like that of *T. megotara*, Hanl.; it is a curved, very slightly twisted, shortish narrow ribbon projecting rather directly towards the lower point of the valve; its front edge is slightly roughened but not thinned out; the inside is glossy; above the beak it is shortly reverted along the hinge-line, which is only slightly hollowed out and furrowed. In the belly of the shell two very marked ribs run divergingly from behind the beak to the margin: one, narrow but prominent and well defined, corresponds exactly to the curved sharp impressed line on the outside formed at the junction between the fine horizontal threads of the front area and the stronger perpendicular ones of the middle area; the other has more, though imperfectly, the character of a projecting shelf to strengthen the attachment of the ear. At the narrowed and somewhat inturned point of the shell is the usual rounded tooth or knob.—H. 0·15. B. 0·12.

This species (whose name I have borrowed from my eminent friend of the Washington Smithsonian Institution) is from the south-eastern coast of Madeira, but the precise locality I failed to note. It varies very greatly in the number of the threads on the entire area of its outer surface. On specimens of much the same size I counted of these from 12 to 37. At first sight it seems very like *T. Stutchburii*, de Blainv.; but on closer examination the differences stand strongly out, and the two species may be distinguished at once by the sharp line of demarcation (like that of *Xylophaga dorsalis*, Turt.) between the threads of the front area and those which are their prolongation at right angles down the middle area, and the distinction is even more visible in the fine

but very distinct white riblet which on the inner face of the shell follows this external line. A similar feature seems to exist in the *T. chlorotica*, Gould, a Pacific Ocean species which unfortunately I know only from description, and that (both of Gould * and Tryon †) is too vague and too divergent from the Madeiran shells to allow of guesses as to its relation to the species from Madeira, of which, moreover, the pallets are wanting.

INDEX-LIST

OF THE SEA-DWELLING MOLLUSCA OF MADEIRA.

I have called this an Index-List in justification of the alphabetical arrangement adopted.

Geographical details will be found in the Presidential Address to the Conchological Society for 1890, published in the 'Conchological Journal,' vol. vi. no. 11, July 1891; and it will suffice to note here that a special interest attaches to Madeira from its position as a point where the Mollusca of Western Europe, of the Mediterranean, of West Africa, and even of the North Atlantic and Eastern North America, find a centre of convergence. The list of collecting stations is given below.

To the specific names which follow are added for each the author's name, and the title and date of the publication in which it appeared, with the addition of at least one reference to some easily accessible illustrated work. Somewhat more is added where difficulty more or less obvious exists. Novelties in nomenclature have been shunned. Except when actually wrong, authors have been left to their own mode of spelling, with a general impression that, as in the instance of the word Gasteropod, it is a little presumptuous to correct Cuvier when backed by Homer in declining γαστήρ. Subgenera have been very sparingly introduced, and the writer has abstained as much as possible from manufacturing species out of those trifling variations to which every living creature is subject.

Two lists of the Mollusca of Madeira have been already published: the one of McAndrew, presenting in his Report to the British Association of 1850 the results of his collecting and

* Gould, Inverteb. of Massachusetts, 2nd. ed. p. 33, fig. 360.

† Tryon, Amer. Mar. Conch. p. 131, figs. 292 to 294.

dredging during "a few days spent in the Madeira islands;" the other, published in 1889, that of Prof. Nobre, enumerating the species collected by Mr. Ernesto Schmitz of the Seminario de Funchal.

McAndrew individualizes 156 (I follow his reckoning) species, but 29 are unnamed, and of the remaining 127, three (*Dentalium dentalis*, *Marginella guancha*, and *Neritina viridis*) have crept in by mistake, and with almost equal certainty the same may be said of four others (viz. *Poromya granulata*, *Pectunculus siculus*, *Murex cristatus*, and *Amphisphyra hyalina*). Besides these, four were wrongly identified, viz. *Bulla ampulla*, *Chiton fascicularis*, *Pecten maximus*, and *P. opercularis*; finally, *Rissoa purpurea*, probably a slip for *R. violacea*. Thus 12 more have to be deducted, leaving 115.

The other list, "Contribuciões para a Fauna Malacologica de Madeira," was published in the 'Instituto,' no. 3, 1889 (Porto), by Senhor Augusto Nobre. It contains the names, but barely more, of 93 species: one of these, *Litorina canariensis*, d'Orb., is merely the young form of *L. striata*, which also occurs in the list; another, *Trochus conuloïdes*, is a re-duplication of *T. zizyphinus*. Five more, viz. *Mytilus edulis*, *Tellina serrata*, *Natica flammulata*, *N. Alderi*, *N. Josephina*, "dredged at Funchal," require confirmation. *Marginella Philippi* calls for further examination. Eight, therefore, of Nobre's 93 species must for the present be, I think, excluded *. Of the 85 which remain, 59 were already given by McAndrew, so that 26—not an inconsiderable addition—swell McAndrew's list of 115 to a total of 141 known species in all. To these I now add 35 new species and 206 previously determined species—that is, 241; bringing up the entire number of observed Mollusca from the Madeiran sea to 382.

This result has come about through a combination of circumstances not very usual. During ten years' residence in Madeira I had opportunity to collect and dredge. In 1874 the collections of the Rev. R. T. Lowe, continued from 1827 to 1872, were sent to me by his literary executor, my lamented friend Mr. T. V. Wollaston. In 1896 Mr. J. Yate Johnson (instead of himself publishing, as I had long hoped he would do) sent to me his

* Fuller criticism of this List will be found in the Presidential Address to the Conchological Society, 1890, *l. c. supra*. Six more of the species given in the List should, I fear, have been excluded: see, at the end here, a strange list of dredging products.

very valuable collection, the accumulation of very many years. The mutual relations of these different collections are supplied in the following list, where, for the sake of shortness, M. represents McAndrew; L., Lowe; N., Nobre; Jn., Johnson; and W., Watson.

If my reference to dredging-depths is somewhat indefinite, it is so left on purpose. Unable personally to superintend this dredging, I have only the boatmen's testimony to the obedience rendered to my order that dredging should go down to 50 fms. One, indeed, of my four boatmen was honest, but truthfulness is not a notable characteristic of the Funchal boatmen; and it is not in human nature, uncoerced, to do more troublesome work at 50 fms. than the easier at 20 or 30—especially when to those engaged the work appears silly, and their employer is regarded as a madman.

I have gratefully to acknowledge counsel and help from the late Dr. Gwyn Jeffreys, from Mr. Edgar A. Smith of the British Museum, and from the Marquis of Monterosato. To the last especially I am indebted for determining (and that with Mediterranean specimens sent me for comparison) the very hopeless wave-beaten fragments of Vermetidæ with which I have had to deal.

Names and Depths of Dredging or Collecting Stations.

Caniçal, towards east end of the Island. 10 to 15 fms.

Cruz, Santa; 7 to 8 miles east of Funchal. 10 to 50 fms.

Cruz, Porto da. North coast to deep water.

Cruz, Punta da. Shore to deep water. Two miles west of Funchal.

Desertas shore. Islands 20 to 30 miles S.E. of Funchal.

Funchal. Shore to 50 fms.

Gorgulho, Fort. Shore west of Funchal, and some shallow dredging.

Labra *; bay east of Caniçal. Depth uncertain.

Lourenço, Punta São, extreme east end. 15 miles from Funchal; to 50 fathoms.

* *Abra* is Arabic for a bay or mooring-place; the letter *L* of the Madeiran name is probably the article. The Moorish "reivers" for long found the island a happy hunting-ground.

Machico; east of Santa Cruz. 10 to 15 fms.

Magdalena; 13 miles west of Funchal. Shallow. A jar, however, with some shells within it was brought up entangled in a fisherman's line from 100 fms.

Moniz, Porto; the furthest north, and almost the furthest west, point of the north coast. Shore.

Piedade; south coast near the east end. 25 to 35 fms.

Ribeiro Secco; north coast off Fayal. 10 fms.

Santo, Porto. Large island 35 miles north-east of Madeira. Shore to 50 fms.

Seixal; shore, north-west coast.

Selvagens. Uninhabited islands, some 200 miles south of Madeira. Shore.

Index-List of Species.

1. *Acera bullata*, 1776, Müller, Prod. Zool. Dan. p. 242. no. 2921, and Zool. Dan. II. lxxi. 1–5: Gwyn Jeffreys, Brit. Conch. IV. 430, viii. 3; & V. xcv. 1. *Hab.* From the Lofotens to the Mediterranean. (W.) S.W. coast from Funchal to Punta de São Lourenço, 10 to 50 fms. My specimens are many but small.

Acirsa, see *Scalaria*.

2. *Aclis* (*Hemiaclis*) *ascaris*, 1819, Turton (as *Turbo*), Conch. Dict. p. 217: Gwyn Jeffreys, Brit. Conch. IV. 102; & V. 210, lxxii. 2. *Hab.* From Shetland to the Adriatic. (W.) Caniçal and Funchal, 10 to 50 fms. Not common.
3. *Aclis supranitida*, 1842, S. Wood (as *Alvania*), Ann. & Mag. IX. 534, pl. V.: Gwyn Jeffreys, Brit. Conch. IV. ii. 4; & V. 210, lxxii. 3. *Hab.* From Norway to the Adriatic and Ægean. (W.) Caniçal and Funchal, 10 to 50 fms. Not common.—McAndrew's collection in the Brit. Mus. contains this species from the Canaries, but it is not named in his Report.
4. *Aclis tricarinata*, 1897, Wats. *antea*, p. 255.
5. *Aclis trilineata*, 1897, Wats. *antea*, p. 255.
6. *Aclis* (*Cioniscus*) *unica*, 1803, Montagu (as *Turbo*), Test. Brit. II. 299: Gwyn Jeffreys, Brit. Conch. IV. 100; & V. 210, lxxii. 1. *Hab.* Norway to the Adriatic and to St. Helena. (W.) Caniçal, Funchal, &c. Not common.
7. *Aclis* (*Cioniscus*) *vitrea*, 1897, Wats. *antea*, p. 254.—Dr. Gwyn Jeffreys (Lightn. & Porcup. Moll., P. Z. S. May 20, 1884,

p. 344) gives *Aclis* (*Pherusa*) *Gulsonæ*, Clerk, as Madeiran on my authority. I am not aware that I ever thought so; if I did I was mistaken. *A. vitrea* sent by me was probably the species which led to the mistake on Dr. Gwyn Jeffreys's part.

8. *Acmæa virginea*, 1776, Müller (as *Patella*), Zool. Dan. Prod. I. pl. xii. 4, 5: Gwyn Jeffreys, Brit. Conch. III. 248; & v. 200, lviii. 4. *Hab.* Doubtfully Arctic or Mediterranean. It extends from Iceland (*Torell*) to Mogador (*McAndrew*). (L., Jn., W.) From Funchal along the whole south-east coast and also to Porto Santo. Very common.

9. *Actæon pusillus*, 1843, Forbes (as *Tornatella*), B. Assoc. Rept. Ægean Inverteb. p. 191; Watson, Chall. Rep. p. 627; Dall, 'Blake' Rep., Harv. Coll. Bull. XVIII. 39. *Hab.* North Atlantic from Cuba to Mediterranean, 40 to 1456 fms. (W.) Magdalena, 100 fms., in an old jar entangled in a fishing-line; Punta de São Lourenço, 50 fms. 3 specimens.

10. *Actæon tornatilis*, 1767, Linné (as *Voluta*), Syst. Nat. p. 1187: Gwyn Jeffreys, Brit. Conch. IV. 433, viii. 4; & v. 224, xcv. 2. *Hab.* From the Lofotens to the Mediterranean and Mogador. (W.) Funchal.—I have three specimens given me as from Funchal; other specimens, too, I have seen said to be from the same locality. I never found it, but (hesitatingly) accept it as Madeiran on the strength of these specimens and the fact that both McAndrew and Lowe got it at Mogador.

11. *Adeorbis subcarinatus*, 1803, Montagu (as *Helix*), Test. Brit. II. 438, vii. 9: Gwyn Jeffreys, Brit. Conch. IV. 231, iii. 5; & v. 216, lxxix. 1. *Hab.* From the English Channel to the Adriatic and the Ægean. (W.) From deep water. One specimen.

Alvania, see *Rissoa*.

12. *Amphidesma castanea*, 1803, Montagu (as *Donax*), Test. Brit. p. 573: Gwyn Jeffreys, Brit. Conch. II. 413, viii. 1; & v. 188, xliii. 1. From the English Channel to the Canaries. (M., L., N., Jn., W.) Everywhere; very common.

13. *Amphisphyra flava*, 1897, Watson, *antea*, p. 234.

14. *Anomia ephippium*, 1767, Linné, Syst. Nat. p. 1150: Gwyn Jeffreys, Brit. Conch. II. 30, i. 4; & v. 165, xx. 1. *Hab.* From Iceland to Madeira, and from N. America to the Black Sea. (M., L., N., Jn., W.) Funchal. Not common.

15. *Aplysia punctata*, 1803, Cuvier, Ann. Mus. II. 295, i. 2–5:

Gwyn Jeffreys, Brit. Conch. v. 5, i. 1 & xcvii. 1. *Hab.* From Norway (see Sars, Moll. Norv. p. 363) to the Mediterranean and Canaries. (M., W.) From Funchal eastwards, 10 to 50 fms. Not uncommon.

16. *Aplysia ocellata*, 1839, d'Orbigny, Moll. Canar. p. 44, v. 1–4. *Hab.* Canaries. (W.) From west of Funchal to the extreme E. point of the island, from the shore to 50 fms. Many young shells.—Mr. Pilsbry (Manual, 1st ser. XVI. 76) adopts *A. dactylomela*, Rang, for this species, but gives no explanation of his passing-by d'Orbigny's express statement that they cannot be united—a statement he would not have made hastily.

17. *Arca diluvii*, 1802, Lamarck, Ann. Mus. VI. 219; An. s. Vert. 1819, VI. (1) 45, 2nd ed. (1835) VI. 476, note of Deshayes; Philippi, Enumeratio, I. 59 (as *A. antiquata*), II. 43, pl. v. 2. *Hab.* Mediterranean to Canaries. (W.) Funchal, 50 fms. 3 separate valves.—On the strength of the habitat I admit this species, but with the gravest doubt.

18. *Arca nodulosa*, 1776, Müller, Zool. Dan. Prod. p. 247: Gwyn Jeffreys, Brit. Conch. II. 180; & v. 176, c. 2. *Hab.* From Norway to the Mediterranean and Adriatic. (L., Jn.) A few living specimens from 10 to 30 fms., dredged in Labra near the extreme E. point of the island.

19. *Arca pectunculoïdes*, 1834, Scacchi, Ann. Sicil. VI. 82; Philippi, Enum. II. 44, xv. 3; Forbes & Hanley, Brit. Moll. (as *A. raridentata*) II. 241, xlv. 8. *Hab.* From Greenland to Mediterranean. (Jn.) One specimen, with the valves united.

20. *Arca plicata*, 1795, Chemnitz, Conch.-Cab. XI. 244, cciv. 2008; Beechey (as *A. gradata*), Voy. 'Blossom,' p. 152, xliii. 1; E. A. Smith (as *A. domingensis*, Lam.), 'Challenger' Lamellib. p. 265.—Lischke traces this species (as *A. domingensis*, Lam.) under most of its synonyms from Japan to Australia, to Natal, to the S. Pacific, to Panama, to the West Indies, the Red Sea, and the E. coast of Africa. In the face of such a record I have not the courage to refuse right of citizenship in Madeira to the two rather undergrown, much weathered, but still quite recognizable specimens which I got from deepish water at Punta de São Lourenço, the eastern point of Madeira, and which alone represent the species in the island.

21. *Arca scabra*, 1795, Poli, Test. Sicil. II. 145, xxv. 22; Kobelt, Conch.-Cab. 2nd ed. VIII. pt. 2, p. 141, xxxvi. 5, 6. *Hab.* Mediterranean.—Mr. Lowe got, in Labra near Punta de São Lourenço, in 1829, one valve of an *Arca* in crevices of a stone with *Gorgonia.* It differs from all the other Madeiran species, and I feel constrained to accept his determination of it.
22. *Arca tetragona*, 1795, Poli, Test. Utr. Sicil. II. 137, xxv. 12, 13: Gwyn Jeffreys, Brit. Conch. II. 180, iv. 5[a]; & v. 176, xxx. 6. *Hab.* From Finmark to the Mediterranean and the Canaries. (M., L., N., Jn., W.) Everywhere, very common, but scarcely ever full-grown.
23. *Argiope decollata*, 1784, Chemnitz (as *Anomia*), Conch.-Cab. VIII. 96, lxxviii. 705: Gwyn Jeffreys, Brit. Conch. II. 18; & v. 164, xix. 3. *Hab.* From Guernsey to the Ægean and the Canaries. (M., L., Jn., W.) Very common.
24. *Argonauta argo*, 1758, Linné, Syst Nat. p. 708; Woodward, Manual Moll. p. 66, fig. 32. (W.) Porto Santo. One perfect specimen.
25. *Assiminea litorina*, 1825–30, d. Chiaje (as *Helix*), Mém. An. s. Vert. III. 215, xlix. 36–38: Gwyn Jeffreys, Brit. Conch. v. 101, xcvii. 6. *Hab.* S.W. England to Mediterranean and Tenerife. (L., Jn., W.) Madeira and Selvagens. Not uncommon.
26. *Atlanta Peronii*, 1817, Lesueur, Jour. de Phys. LXXXV. 390, ii. 1; Woodward, Man. Moll. p. 200, pl. xiv. 21–23.—A pelagic species. Everywhere; Madeira and Porto Santo. Common.
27. *Atys Jeffreysi*, 1868, Weinkauff (as *Cylichna*), Conch. Mittelm. II. 199; Monterosato, Nomenclatura, p. 145 (as *Roxaniella*).—No good figure exists of this species. Brocchi, who (*teste* Philippi) erroneously identified it with *Bulla ovulata*, Lam., gives a figure which resembles *B. redacta*, Desh., much more than it resembles either the *B. ovulata*, Lam., or the Mediterranean or Madeiran species. Jeffreys's figure (Ann. & Mag. 1856, vol. XVII. 188, ii. 18, 19), though better, is not characteristic. The *B. semistriata*, Desh. Coq. foss. Paris, II. 44, pl. v. 27, 28), offers as good a representation of this species as any I know.—*Hab.* Mediterranean. (N., Jn., W.) Everywhere; excessively common.
28. *Auricula æqualis*, 1832–34, Lowe (as *Melampus*; 1854, *Auricula*), Zool. Jour. v. 288, xiii. 1–5; Gray, Moll. Anim. III.

cccv. 3, copied from Lowe as *Cassidula*. *Hab.* Under stones below high-water mark at the East end and along the whole North coast of the island; also at the Selvagens. Unknown elsewhere. (L., Jn., W.) Very common.—Pfeiffer, Zool. Blätter, XIII. (1866), gives this species on the authority of de Paiva as from the South coast as well; but de Paiva's collectors are not to be trusted.

29. *Auricula gracilis*, 1832–4, Lowe (as *Melampus*; 1854, *Auricula*), Zool. Jour. v. 288; Morelet (as *A. vespertina*), Hist. Nat. Açores, p. 210, pl. v. 9. *Hab.* Under stones below high-water mark on North shore in fissures of the rocks; also at the Selvagens. Always rare. Unknown elsewhere. (L., W.)

30. *Auricula Paivana*, 1866, Pfeiffer (as *Alexia*), Mal. Blätt. XIII. 146; Wollaston, Test. Atlantic. p. 295. Unfigured. *Hab.* Under stones below high-water mark in the Selvagem Grande, and there common: unknown elsewhere. (W.) I follow Wollaston in giving this on Pfeiffer's authority as a distinct species, though, as Wollaston mentions, Dr. Fischer shared my opinion that it is a mere variety of *A. bidentata*, Mont.

31. *Auricula Watsoni*, 1878, Wollaston, Test. Atlant. pp. 269, 295. Unfigured. *Hab.* North coast, under high-water mark. Selvagens: rare. Unknown elsewhere. (W.)

32. *Avicula hirundo*, 1769, Linné (as *Mytilus*), Syst. Nat. p. 1159: Gwyn Jeffreys, Brit. Conch. II. 95, ii. 3; & v. 178, xxv. 6. *Hab.* From Channel Islands to Mediterranean and Canaries. (M., L., Jn., W.) From Funchal along the coast eastwards; also Porto Santo. 10 to 50 fms.

33. *Axinus croulinensis*, 1847, Jeffreys, Ann. & Mag. xx. 19, ser. 3, II. 122, v. 2: Brit. Conch. II. 250; & v. 180, xxxiii. 2. *Hab.* From the Lofotens to the Mediterranean. (W.) Rather common.

34. *Bifrontia zanclea*, 1844, Philippi, Enum. II. 225, xxviii. 11; Sowerby, Manual, 4th ed. p. 84, xvi. 354–6; Woodward, Manual, p. 135; Kobelt, Prodromus, p. 218 (as *Omalaxis*). *Hab.* Mediterranean: in a few localities. Everywhere; very common. (M., N., Jn., W.)—Of course every one knows that a good deal may be said against the generic name here adopted, but even more perhaps can be urged in its favour, and especially while so little is known of the animal

it may be permissible to retain an old friend, whom if we forsake to whom shall we turn. *Omalaxis* of Deshayes is like one of Adanson's facetious names. *Homalalaxis* of Herrmansen is fatuous. *Homalaxis* is a hybrid, neither Greek nor Latin. *Torinia* is a mere guess, and thereafter the mazes of *Ilaira*, *Euomphalus*, *Evomphalus*, *Omalaxon*, *Pseudomalaxis*, &c. may well send us back thankfully to *Bifrontia*, where if we are ignorant we are at least humble. Monterosato (Conch. d. profundita &c. Palermo, p. 16), who adopts the last of the above-quoted generic names, rejects the identification of this Madeiran species with that of Philippi. His opinion deserves the utmost respect, but I am not able to adopt it in this case.

35. *Bittium depauperatum*, 1897, Watson, *antea*, p. 245.

36. *Bittium incile*, 1897, Watson, *antea*, p. 246.

37. *Bittium reticulatum*, 1778, da Costa (as *Strombiformis*), Brit. Conch. p. 117, viii. 13: Gwyn Jeffreys, Brit. Conch. IV. 258, iv. 4; & V. 217, lxxx. 4. *Hab.* From the Lofotens (*Lovén*) to Mediterranean and Canaries. (M., L., N., Jn., W.) Everywhere; very common.

38. *Bulla* (*Haminea*) *hydatis*, 1767, Linné, Syst. Nat. p. 1183: Gwyn Jeffreys, IV. 437, viii. 5; & V. 224, xcv. 3. *Hab.* Gt. Britain to Mediterranean, Canaries, and St. Helena. (W.) Not common and small.

39. *Bulla punctata*, 1868, A. Adams, Cuming's Collection, *teste* Sowerby in Reeve's Conch. Icon. XVI., *Bulla* sp. 15. Not *Bulla punctulata* (so in Explanation of Plates and Index, pp. 604 & 607, corrected from *B. punctata* of the text) of Sowerby's Thesaurus; not *Bullæa punctata* of John Adams, Trans. Linn. Soc. V. 1, pl. i. figs. 1, 2, where there is a *Philine*, and which in Sowerby's Thesaurus, II. 600, cxxv. 161, is given by A. Adams as *B. punctata*; nor is it the *Bulla punctata* or *punctulata* of C. B. Adams, which (*teste* Carpenter) is the *B. Adamsi*, Mke.; nor the *Atys* (*Roxania*) *punctulata* of A. Adams. Whether Pilsbry's Manual of Conch. contains the species is, I think, very doubtful; the figure pl. xxvii. 40, 41, taken from Reeve, not good in the original, is not mended in the copy.—*Hab.* Madeira and Canaries (*f.* McAndrew, who gives it as *Bulla ampulla*). (L., Jn., W.) Everywhere; pretty frequent, especially young shells.

40. *Cadulus Jeffreysi*, 1875, Monterosato (as *Helonyx*), Nuova Revista, p. 20. no. 293; Gwyn Jeffreys, Brit. Conch. v. 196, ci. 3 (as *Siphonodentalium subfusiforme*, Sars). *Hab.* Gt. Britain to the Mediterranean and to St. Helena. (Jn., W.) Rare.
41. *Cæcum atlantidis*, 1897, Watson, *antea*, p. 248.
42. *Cæcum glabrum*, 1803, Montagu (as *Dentalium*), Test. Brit. p. 497: Gwyn Jeffreys, Brit. Conch. IV. 77; & v. 209, lxx. 5. *Hab.* From Norway to Mediterranean and Canaries. (W.) Punta de São Lourenço. One specimen.
43. *Cæcum trachæa*, 1808, Montagu (as *Dentalium*), Test. Brit. II. 497, xiv. 10: Gwyn Jeffreys, B. C. IV. 75, i. 6; & v. 209, lxx. 4. *Hab.* From Scotland to Mediterranean, Canaries, and Cuba. (W.) P. de São Lourenço. One broken specimen.
44. *Cæcum vitreum*, 1858, Carpenter, P. Z. S. p. 432. no. 29; Tryon, Man. Conch. VIII. 215, lxvi. 54 (see McAndrew, Canarian List, p. 31, as *C. glabrum*). Japan (see A. Adams, Ann. & Mag., Nov. 1868). (W.) Everywhere very common, in Funchal Bay especially.—The name alone of this species, but without description, bears an earlier date than that given above.
45. *Calyptræa chinensis*, 1767, Linné (as *Patella*), Syst. Nat. p. 1257: Gwyn Jeffreys, Brit. Conch. III. 273, vi. 6; & v. 201, lx. 1. *Hab.* From English Channel to Black Sea and Canaries. (M., L., N. Jn., W.) Everywhere; very common.
46. *Cancellaria minima*, 1856, Reeve, Conch. Icon. sp. 77; Kobelt, Mart. & Chemn. Conch.-Cab. 2nd ed. IV. pt. 4, p. 81, pl. xxi. 3, 4. *Hab.* Straits of Gibraltar, Madeira. (L., Jn., W.) Everywhere; very common.
47. *Capulus hungaricus*, Linné (as *Patella*), Syst. Nat. p. 1259: Gwyn Jeffreys, Brit. Conch. III. 269, vi. 5; & v. 201, lix. 6. *Hab.* From North Finmark to Mediterranean. (L., Jn., W.) Funchal and Punta de São Lourenço, 10 to 40 fms. The pullus shells very common; only one full-grown shell.
48. *Cardita calyculata*, 1767, Linné (as *Chama*), Syst. Nat. p. 1138; Born, Mus. Cæs. Vindob. pl. v. 10, 11; Poli, Test. Sicil. II. xxiii. 7–9. *Hab.* Iberian Peninsula, Mediterranean, Canaries. Everywhere—Madeira, Porto Santo; the Selvagens. Semi-fossil, Caniçal beds. Very common.
49. *Cardium aculeatum*, 1767, Linné, Syst. Nat. p. 1122: Gwyn Jeffreys, B. C. II. 268; & v. 180, xxxiv. 1, 1[a]. *Hab.* From

S. England to Mediterranean. (L., N., Jn., W.) Everywhere very common, but small.

50. *Cardium exiguum*, 1789, Gmelin, Syst. Nat. p. 3255: Gwyn Jeffreys, B. C. II. 278; & v. 181, xxxv. 2. *Hab.* Extant from the later Tertiaries it extends from North Norway to the Black Sea. (N.) Dredged at Caniçal it must, on Senr. Nobre's responsibility, be admitted here.

51. *Cardium norvegicum*, 1792, Spengler, Scrivt. Nat. Selskab. v. (1) p. 42: Gwyn Jeffreys, B. C. II. 294; & v. 182, xxxv. 7. *Hab.* From North Norway to Canaries. (M., L., N., Jn., W.) Everywhere; common, but small.

52. *Cardium papillosum*, 1791, Poli, Test. Sicil. I. 56. xvi. 2–4: Gwyn Jeffreys, II. 275; & v. 181, xxxv. 1. *Hab.* From the Channel Islands to Mediterranean and Canaries. (M., L., N., Jn., W.) Everywhere; very common.

53. *Cardium transversale*, 1854, Deshayes, P. Z. S. p. 333; Smith, 'Challenger' Report, p. 162, viii. 3. *Hab.* Alboran Islands, Mediterranean; Açores to Canaries. (Jn., W.) Everywhere; extremely abundant.

54. *Cardium tuberculatum*, 1767, Linné, Syst. Nat. p. 1122: Gwyn Jeffreys, B. C. II. 273; & v. 181, xxxiv. 3. *Hab.* Great Britain to Mediterranean and Canaries. (M., L., N., Jn., W.) Everywhere; very common.

55. *Carinaria Lamarckii*, 1810, Péron & Lesueur, Ann. Mus. xv. 69, iii. 15; Gray, Fig. Moll. II. pl. clxi. 1 (as *C. mediterranea*); Woodward, Man. Moll. p. 200, fig. 105, pl. xiv. 19 (as *C. cymbium*). *Hab.* Mediterranean. (L., W.) Floating alive off the Desertas. Fry rare in dredgings.

Cassidula, see *Auricula*.

Cassis saburon, 1757, Adanson, Coq. Sénégal, p. 112. no. 8, pl. vii. 8; Bruguière, Dict. Encycl. I. 420. no. 4; Lamarck, An. s. Vert. VII. 227, 2nd ed. (Deshayes) x. 36. no. 21. *Hab.* From the Bay of Biscay to the Mediterranean, Mogador, and Senegal; but it has not been recorded from the Canaries. I never found it nor have seen it from Madeira, and the shells labelled as this species in Lowe's collection belong to *C. sulcosa*. Having it therefore as Madeiran on Senr. Nobre's authority alone, with no information beyond the name, and in absence from his list of the common *C. sulcosa*, I may, I trust, without discourtesy, hold the species as more than doubtfully Madeiran.

56. *Cassis sulcosa*, 1780, Born (as *Buccinum*), Mus. Cæs. Vind. p. 241; Lamarck, An. s. Vert. VII. 226, 2nd ed. vol. x. 34. no. 19; Wood, Ind. Test. pl. xxii. 25. *Hab.* Mediterranean

to Madeira. (M., L., Jn., W.) Nearly everywhere; very abundant.

57. *Cavolina** *gibbosa*, 1828?, Rang (as *Hyalæa*) in d'Orb. Voy. Amér. Mérid., Moll., 1836–43, p. 97, pl. v. figs. 21–25; Souleyet, Voy. 'Bonite,' Zool. II. 144, iv. 13–19; and Ptérop. p. 38, x. 3, 4; Pelseneer, 'Challenger' Report, pt. 65, p. 82. *Hab.* Pelagic. (L., Jn., W.) Rare.

58. *Cavolina inflexa*, 1813, Lesueur (as *Hyalæa*), Nouv. Bull. Soc. Phil. III. 285. no. 69, pl. v. 4. A, B, C, D; d'Orbigny, Voy. Amér. Mérid., Moll. v. 103, vi. 16–20; Lamarck, An. s. Vert. 2nd ed. VII. 422. no. 16; Souleyet, Ptérop. p. 41, iii. 9–12; Pelseneer, 'Challenger' Report, pt. 65, p. 85. *Hab.* Pelagic. (M., Jn., W.) Common. *Note*—McAndrew gives this as *Hyalæa vaginella*.

59. *Cavolina quadridentata*, 1821, Lesueur (as *Hyalæa*) in Blainville, Dict. Sc. Nat. vol. XXII. p. 81; d'Orbigny (as *H. quadrispinosa*), Voy. Amér. Mérid., Moll. v. 85, vi. 1–5; Pelseneer, 'Challenger' Report, pt. 65, p. 78. *Hab.* Pelagic. (Jn., W.) Not uncommon.

60. *Cavolina tridentata*, 1775, Forskål (as *Anomia*), Descrip. Anim. Itin. orient. p. 124, and Icon. pl. xl. fig. *b*; Woodward, Manual, p. 204, fig. 107, & xiv. 32; Pelseneer, 'Challenger' Report, pt. 65, p. 83. *Hab.* Lands End to Eastern America; Mediterranean to Canaries. (M., L., W.) Rare.

61. *Cavolina trispinosa*, 1821, Lesueur (as *Hyalæa*) in Blainville, Dict. Sc. Nat. XXII. 82; Souleyet, Ptérop. p. 45, pl. iii. 1–7; Voy. 'Bonite,' II. 161, vi. 1–10. Of general distribution. (Jn., W.) Common.

62. *Cerithiopsis atalaya*, 1885, Watson, Cerithiopsides from N.E. Atlantic, Journ. Linn. Soc., Zool. XIX. p. 94, pl. iv. 9, 9*a*. *Hab.* Madeira. (Jn., W.) From Funchal to Punta de São Lourenço. Not uncommon.

63. *Cerithiopsis diadema*, 1885, Watson, Cerithiopsides from N.E. Atlantic, Jour. Linn. Soc., Zool. XIX. p. 93, pl. iv. 8; Gwyn Jeffreys, Moll. Lightn. & Porcup., P. Z. S. 1885, p. 60, vi. 9, 9 *a*. *Hab.* Madeira and Mediterranean. (W.) From Funchal eastwards to Punta de São Lourenço. Frequent.

* *Note*—So Abildgaard wrote his proposed genus. It would be curious to learn by what authority names, except when wrong, are changed. If *Cavolinia* and all the host of emendations so dear to the *doctrinaire* mind be adopted, where shall change be checked? Are we seriously enamoured of a fresh Babel?

64. *Cerithiopsis fayalensis*, 1885, Watson, Cerithiopsides N.E. Atlantic, Jour. Linn. Soc., Zool. XIX. p. 92, iv. 5–5 *a*; 'Challenger' Report, Moll. p. 527, pl. xxx. 2. *Hab.* Mediterranean, Portugal, Açores to Madeira. (W.) Frequent.

65. *Cerithiopsis Jeffreysi*, 1885, Watson, Cerithiopsides N.E. Atlantic, Journ. Linn. Soc., Zool. XIX. 90, iv. 2; Gwyn Jeffreys (as *C. pulchella* but not of C. B. Adams), Ann. & Mag. 3rd ser. II. 129, v. 8; Brit. Conch. IV. 269, & v. 217. *Hab.* English Channel to Mediterranean. (W.) Rare. Monterosato (*in litt.*) suggests that Conti's name of "*concatenata*" should have precedence: see Conti, Foss. di Monte Mario; but there are other questions, besides, regarding the species which had need of settlement before further disturbance of the name.

66. *Cerithiopsis Metaxa*, 1829, d. Chiaje (as *Murex*), Mém. An. s. Vert. III. 222, pl. xlix. 29–31; Tiberi (as *Cerithium Crosseanum*), Jour. de Conch. 1863, p. 160, vi. 2: Gwyn Jeffreys, B. C. IV. 271; & v. 217, lxxxi. 4. *Hab.* Shetland to Mediterranean and Canaries. (M., L., N., Jn., W.) Everywhere; common.

67. *Cerithiopsis minima*, 1864, Brusina (as *Cerithium*), Conch. Dal. p. 17; Bucquoy, Dautzenberg, & Dollfuss, Moll. Rouss. p. 207, xxvii. 5–9. *Hab.* Mediterranean. (W.) Very rare.

68. *Cerithiopsis tiara*, 1885, Watson, Cerithiopsides N.E. Atlantic, Jour. Linn. Soc., Zool. XIX. p. 92, iv. 6, 6 *a*. *Hab.* Madeira and Mediterranean. (W.) From Funchal eastwards to Punta de São Lourenço. Not uncommon.

69. *Cerithiopsis tubercularis*, 1803, Montagu (as *Murex*), Test. Brit. I. 270: Gwyn Jeffreys, B. C. IV. 266, iv. 5; & v. 217, lxxxi. 1. *Hab.* Norway to Mediterranean. (W.) From Funchal eastwards to the Point of the Island and to Porto Santo. Not uncommon.

70. *Cerithium rupestre*, 1826, Risso, Hist. Nat. Europ. IV. 154; Philippi, Enum. I. 194, xi. 7. *Hab.* Mediterranean. (L., Jn.) Selvagens, *fide* Barão de Paiva.

71. *Chama gryphoïdes*, 1767, Linné, Syst. Nat. p. 1139; Woodward, Man. p. 276, xviii. 8, 9 (as *C. macrophylla*, Chemn.). *Hab.* Bay of Biscay to Mediterranean and Canaries. (L., N.?, Jn., W.) Everywhere; very common.—It is curious

McAndrew, whose collection has 10 specimens from the Mediterranean and Canaries, did not get it.

Chascax, see *Fasciolaria armata*.

72. *Chiton cancellatus*, 1839, G. B. Sowerby, Conch. Illustr. no. 5, figs. 104–5: Gwyn Jeffreys, B. C. III. 217; & V. 198, lvi. 1. From Sweden and Norway to Mediterranean. (L., Jn., W.) From west of Funchal to East point and Porto Santo. Common.

73. *Chiton* (*Acanthochiton*) *discrepans*, 1827, Brown, Ill. Conch. p. 65, xxi. 20: Gwyn Jeffreys, B. C. III. 214; & V. 198, lv. 4. Channel Islands to Mediterranean and Mogador. (M., as *C. fascicularis*; L., Jn., W.) Everywhere; very common.

74. *Chiton* (*Callochiton*) *levis*, 1767, Pennant, Brit. Zool. IV. 72, xxxvi. 3; Philippi, Enum. I. 107, vii. 4, II. 83: Gwyn Jeffreys, B. C. III. 226; & V. 199, lvi. 6. *Hab.* From Northern Norway to Mediterranean and Canaries. (W.) From Funchal eastwards and Porto Santo. Specimens not rare, but all small.

75. *Chiton* (*Ischnochiton*) *marginatus*, 1767, Pennant, Brit. Zool. IV. 71, xxxvi. 2: Gwyn Jeffreys, B. C. III. 221; & V. 199, lvi. 5. *Hab.* From Lofotens to Sicily and Mogador. (M., as *C. cinereus*; L., W.) Caniçal, near Punta de São Lourenço. Very rare.

Chiton (*Ischnochiton*) sp.—Dr. Gwyn Jeffreys considered this to be *C. Rissoi*, Payr.; but out of 30 or 40 very small and separate valves which I collected, about half are those of the head alone, not one is of the tail, and on none is the girdle preserved; so that the species cannot be determined with any confidence.

Cioniscus, see *Aclis*.

76. *Circe minima*, 1803, Montagu (as *Venus*), Test. Brit. p. 121, iii. 3: Gwyn Jeffreys, II. 322, vi. 4; & V. 183, xxxvii. 6. *Hab.* From Finmark to Mediterranean and Canaries. (M., L., Jn., N., W.) Everywhere; very common.

77. *Clio* (*Creseis*) *acicula*, 1828, Rang (as *Creseis acicula* and *C. clava*), Ann. Sc. Nat. XIII. 317, xvii. 5, 6; Souleyet, Hist. Ptérop. p. 56, vi. 5, 7; Woodward, Manual, p. 205, xiv. 34. *Hab.* Pelagic. (W.) Everywhere, but not common.

78. *Clio pyramidata*, 1767, Linné, Syst. Nat. p. 1094; Souleyet, Hist. Ptérop. p. 50, v. 7–10; Woodward (as *Cleodora*), Man. p. 205, xiv. 33. *Hab.* Pelagic. (Jn., W.) Everywhere.

79. *Clio striata*, 1828, Rang (as *Creseis*), Ann. Sc. Nat. XIII.

315, xvii. 3; Souleyet, Hist. Ptérop. p. 55, vi. 3. *Hab.* Pelagic. (W.) Funchal Bay; very rare.

80. *Clio* (*Styliola*) *subula*, 1827, Quoy & Gaimard (as *Cleodora*), Ann. Sc. Nat. x. 233, viii. 1–3; Souleyet, Hist. Ptérop. p. 55, vi. 2, 6. *Hab.* Pelagic. (Jn., W.) Everywhere; very common.

81. *Columbella* (*Mitrella*) *cribraria*, Adanson, 'Le Barnet,' p. 146, pl. x. 1; 1822. Lamarck (as *Buccinum*), An. s. Vert. VII. 274. no. 43; Quoy & Gaimard, 'Astrolabe' Moll. II. 421, pl. xxx. 21, 22; Kiener (*Buccinum*), p. 22. no. 23, xvi. 58. *Hab.* Guinea Coast, St. Helena, Ascension, Canaries, West Indies, &c. (M., L., Jn., W.) Funchal to East end of Island. Very common.

82. *Columbella Kraussii*, 1844, Sowerby, P. Z. S. p. 53; Thes. Conch. I. xl. 180; Krauss, Süd-Afrik. Moll. (as *C. cerealis*, Mke., MS.); Sowerby (George), Mar. Shells S. Africa (as *C. cerealis*, Krauss), p. 21. *Hab.* Port Elizabeth, the Cape, and probably the Mediterranean. (L., Jn., W.) Everywhere; common. I also found it at the Canaries.—It is very like *C. catenata*, Sow., in colour; but that species is larger, stouter, and more coarsely ribbed. It is even liker *C. Broderipii*, Sow.; but the Madeiran species is so variable as to suggest much caution. It is the *C. albuginosa*, Reeve, Conch. Icon. XI. no. 223; and probably *C. pediculus*, Monterosato, and some other Mediterranean forms which he individualizes.

83. *Columbella minor*, 1836, Scacchi, Cat. Reg. Neap. p. 10, f. 11; Philippi, Enum. Moll. Sic. II. 190, xxvii. 12. (N., W.) *Hab.* Mediterranean.—This as a species is painfully suggestive of some depauperated forms of *C. scripta*, L., from which, however, since some are willingly responsible for separating it, it may be observed to differ in a slightly finer apex and more delicate spiral threads round the snout; but, as distinctive features, neither colour nor size count for much.

84. *Columbella rustica*, 1767, Linné (as *Voluta*), Syst. Nat. p. 1190; Adanson, 'Le Siger,' p. 135, ix. 28; Philippi, Enumeratio, I. 228, xii. 11. *Hab.* From Bay of Biscay to Mogador and Mediterranean. (M., L., N., Jn., W.) Everywhere; very common.

85. *Columbella scripta*, 1767, Linné (as *Murex*), Syst. Nat. p. 1225;

Kiener, xiii. 43 (as *Buccinum Gervillei*), and xvi. 56 (as *B. corniculum*). *Hab.* Mediterranean. (L., Jn., W.) Magdalena; Funchal; Punta de São Lourenço and Porto Santo. 40 to 50 fms. Not common.

86. *Conus mediterraneus*, 1790, Hwass * in Encycl. Méthod. I. 701, pl. cccxxx. 4; Wood, Index Test. p. 83, pl. xv. 101; Reeve, Conch. Icon. xvi. 89.—I give this species here on the authority of Senhor Nobre. Specimens were occasionally brought to me by Funchal boatmen, but I never considered them Madeiran. A very worn specimen in Mr. Johnson's collection seems rather to confirm my doubts. Still its presence on the coast of Portugal, throughout the Mediterranean, and at the Canaries makes its existence at Madeira anything but unlikely.

87. *Coralliophaga Johnsoni*, 1897, Watson, *antea*, p. 265.

Coralliophila, see *Murex*.

88. *Crania anomala*, 1776, Müller, Prod. Zool. Dan. p. 237; Zool. Dan. I. 4, pl. v. 1–8; Woodward, Man. pp. 235–6, ff. 157–8: Gwyn Jeffreys, B. C. II. 24, i. 3; & v. 165, xix. 6; Davidson, Rec. Brach., Trans. Linn. Soc., Zool. IV. 183, xxvii. 1–9*b*. *Hab.* Greenland and Spitzbergen to Mediterranean. (L., Jn., W.) Funchal, 50 fms. A few valves.

89. *Craspedotus Tinei*, 1830, Calcara (as *Monodonta*), Ricerche Mal. p. 14, t. 8; Philippi, Enum. II. 157, xxv. 19 (as *Monodonta limbata*, but not of Quoy & Gaim., and not a *Monodonta*, being umbilicated and non-nacreous). *Hab.* Mediterranean. (Jn., W.) Funchal, 50 fms. 2 specimens.

90. *Crenella rhombea*, 1827, Berkeley (as *Modiola*), Zool. Jour. III. 229, xviii. 1: Gwyn Jeffreys, B. C. II. 131; & v. 172, xxviii. 5. *Hab.* English Channel to Mediterranean and Canaries. (W.) Funchal, 50 fms. Punta de São Lourenço, 50 fms. Not common.

Crossea, see *Rissoa*.

91. *Cuspidaria costellata*, 1836, Deshayes (as *Corbula*), Morée, p. 86, xxiv. 1–3: Gwyn Jeffreys, B. C. III. 49; & v. 191, xlix. 3 (as *Neæra*). *Hab.* Norway to Mediterranean and Canaries. (M., L., Jn., W.) Everywhere; very common.

92. *Cuspidaria cuspidata*, 1792, Olivi (as *Tellina*), Zool. Adr. p. 101, iv. 3: Gwyn Jeffreys, B. C. III. 53, ii. 4; & v. 191,

* Hwass, *teste* Bruguière, Encycl. Méthod. i. p. 598, wrote the whole article on *Conus*.

xlix. 5. *Hab.* From Spitzbergen and Greenland to Mediterranean and Canaries. (M., L., Jn., W.) Everywhere; common.

93. *Cuvieria columella*, 1827, Rang, Ann. Sc. Nat. xii. 323, xlv. 1–8; Souleyet, Hist. Ptérop. p. 59, pl. iv. & xiv. 1–6; Woodward, Man. p. 205, pl. xiv. 35. *Hab.* Pelagic. (Jn., W.) Not common.

94. *Cyclostrema serpuloides,* 1808, Montagu (as *Helix*), Test. Brit. Suppl. p. 147, xxi. 3: Gwyn Jeffreys, B. C. iii. 290, vii. 3; & v. 201, lxi. 3. *Hab.* From Great Britain to Mediterranean. (W.) From east of Funchal to Punta de São Lourenço, and Porto Santo. Common.

95. *Cylichna cylindracea*, 1767, Pennant (as *Bulla*), Brit. Zool. iv. 117, lxxvii. 85: Gwyn Jeffreys, B. C. iv. 415, viii. 1; & v. xciii. 4. *Hab.* From Finmark to Mediterranean and Canaries and St. Helena. (M., Jn., W.) Everywhere; very common.

96. *Cylichna spreta*, 1897, Watson, *antea*, p. 234.

97. *Cylichna umbilicata*, 1803, Montagu (as *Bulla*), Test. Brit. i. 222, vii. 4: Gwyn Jeffreys, B. C. iv. 413; & v. 223, xciii. 3. *Hab.* From the Lofotens to the Mediterranean. (W.) Santa Cruz, Machico, Caniçal; down to 50 fms. Rare.—These specimens from Madeira were identified as above by Dr. Gwyn Jeffreys: after much hesitation I at length, despairing to mend the instruction, have accepted his determination, which the Marquis of Monterosato still rejects.

98. *Cylindrobulla fragilis*, 1856, Gwyn Jeffreys (as *Cylichna*), Mar. Test. Pied., Ann. & Mag. Feb. 1856, p. 188, ii. 16, 17, & 'Washington' Ital. Exped. Notes, Ann. & Mag. July 1882, p. 34 (as *Cylindrobulla*). *Hab.* Mediterranean, 10 to 1536 fms. (W.) Porto Santo, 50 fms. One specimen.

99. *Cypræa* (*Trivia*) *candidula*, 1835, Gaskoin, P. Z. S. p. 200; Kiener, Iconog. p. 150. no. 136, lii. 1; Reeve, Conch. Icon., Cypræa, sp. 151, 154; Sowerby, Thesaurus, iv. p. 50, pl. xxxvi. ff. 508–9. *Hab.* From Portugal to W. Mediterranean; Canaries and Bight of Benin. (M., L., Jn., W.) Everywhere; very common.

100. *Cypræa* (*Trivia*) *europæa*, 1803, Montagu, Test. Brit. Suppl. p. 88: Gwyn Jeffreys, B. C. iv. 403, vii. 4; & v. 222, xcii. 2. *Hab.* From Norway to Mediterranean. (W.) Punta de São Lourenço. 2 specimens.

101. *Cypræa lurida*, 1767, Linné, Syst. Nat. p. 1175; Kiener, Iconog. p. 82. no. 71, pl. xxiii. 1; Sowerby, Thes. IV. 6, sp. 7, x. 64–5; Reeve, Conch. Icon., Cypræa, sp. 32, pl. ix. 32. *Hab.* Mediterranean to the Cape Verd Is., Guinea Coast, and St. Helena. (W.) Porto Santo. 2 specimens.

102. *Cypræa* (*Trivia*) *pulex*, 1827, Solander, Zool. Jour. III. 368; Kiener, Iconog. p. 142, liii. 1; Reeve, Conch. Icon. sp. 144, pl. xxv.; Sowerby, Thes. IV. 44, pl. xxxvi. 492–4. *Hab.* From Portugal to Mediterranean. (M., L., N., Jn., W.) Everywhere; common.

103. *Cypræa pyrum*, 1790, Gmelin, Syst. Nat. p. 3411; Reeve, Conch. Icon. sp. 26, pl. viii.; Sowerby, Thes. IV. p. 25, pl. xxiv. 202–5. *Hab.* From Portugal to the Canaries. (L., Jn., W.) Porto Santo. Not very common.

104. *Cypræa spurca*, 1767, Linné, Syst. Nat. p. 1179; Kiener, Iconog. p. 61, xxx. 1, 1*a*; Reeve, Conch. Icon., Cypræa, sp. 68, pl. xiv.; Sowerby, Thes. IV. p. 38. no. 131, pl. xviii. 118–122 & xxxvi. 516. *Hab.* From West Indies to Portugal, Mediterranean, Canaries, Mogador, and St. Helena. (L., N., Jn., W.) Punta de São Lourenço and Porto Santo. Plentiful.

Cytheræa, see *Venus*.
Defrancia, see *Pleurotoma*.

105. *Diplodonta rotundata*, 1803, Montagu (as *Tellina*), Test. Brit. p. 71, ii. 3: Gwyn Jeffreys, B. C. II. 254, v. 7; & v. 180, xxxiii. 4. *Hab.* From English Channel to Mediterranean and Canaries. (M., L., N., Jn., W.) Everywhere; very common.

106. *Diplodonta trigonula*, 1831; Bronn, Ital. Tertiär-Geb. p. 96, iii. 2; Philippi, Enumeratio, I. 31, iv. 6, & II. 24 (where he gives both *D. trigonula*, Bronn, and also his own *D. apicalis* as if different); Wood, Crag Moll. II. 146, xii. 2 *a*, *b*; Hörnes, Foss. Moll. Wiener, p. 218, xxxii. 4 *a*, *b*. *Hab.* Mediterranean to Canaries. (M., L., Jn., W.) Everywhere; very common.

107. *Dolium galea*, 1767, Linné (as *Buccinum*), Syst. Nat. p. 1197; Woodward, Man. p. 115, vi. 12. *Hab.* From Portugal to Mediterranean and Canaries. (L., W.) Funchal, Punta de São Lourenço, Porto Santo; 10 to 50 fms. Not uncommon, but the specimens mostly young or in fragments.

108. *Donax trunculus*, 1767, Linné, Syst. Nat. p. 1127: Gwyn Jeffreys, B. C. II. 407; & v. 188, xlii. 7. *Hab.* From Channel Islands to Mediterranean, and (*me ipso teste*) both Canaries and Mogador. (Jn., W.) Porto Santo, &c. Not unfrequent as single valves.
109. *Donax venustus*, 1791, Poli, Test. Sicil. II. xix. 23, 24; Römer in Mart. & Chemn. Conch.-Cab. 2nd ed. x. pt. 3, p. 31, vi. 10–20. *Hab.* Mediterranean. (Jn., W.) From Funchal along South coast, also Porto Santo. Common.
110. *Doridium laurentianum*, 1897, Watson, *antea*, p. 237.
111. *Doridium maderense*, 1897, Watson, *antea*, p. 238.
112. *Emarginula fissura*, 1767, Linné (as *Patella*), Syst. Nat. p. 1261: Gwyn Jeffreys, B. C. III. 259, vi. 3; & v. 200, lix. 2. *Hab.* From Finmark to Mediterranean and Canaries. (M., L., Jn., W.) Everywhere; very common, in every form of transition to *Semperia Paivana*, Crosse, Jour. de Conch. 1867, p. 76, ii. 2.
113. *Emarginula Huzardi*, 1826, Payraudeau, Moll. Cors. p. 92, pl. v. 1, 2; Lamarck ed. Desh. VII. 587. no. 11; Reeve, Conch. Icon. sp. 4; Gwyn Jeffreys, Lightn. & Porcup. Moll., P. Z. S. 1882, p. 679. no. 5. *Hab.* Mediterranean. (L., W.) Funchal, Punta de São Lourenço, Porto Santo. Not common.
114. *Emarginula tenera*, 1878, Monterosato, Enum. & Synon. p. 19 (the name alone); id. Nomenclatura, p. 36; Locard, Malac. Franç. p. 337; Watson MS., *E. alba.*—This species stands much in need of description and figure It is small, translucent, white, high, well-rounded, with about 30 strong ribs and occasional weaker intermediate ones, with small sharp cross-bars and deep lattice-like depressions, having a long, narrow, square-cut, sharply bordered slit; the top is incurved and a little depressed, and directly overhangs the extreme front edge. L. 0·11. B. 0·065. H. 0·05. *Hab.* Bay of Biscay, Mediterranean. (W.) Almost everywhere; not rare.
115. *Eulima badia*, 1897, Watson, *antea*, p. 258.
116. *Eulima fulva*, 1897, Watson, *antea*, p. 256.
117. *Eulima inconspicua*, 1897, Watson, *antea*, p. 260.
118. *Eulima intermedia*, 1842, Cantraine, Malac. Méd. Suppl. (p. 40 ?), Bull. Bruxelles, p. 14 (?): Gwyn Jeffreys, B. C. IV. 203; & v. 214, lxxvii. 5. (*Note.*—Sars's shell, Moll. Norv.

p. 210, pl. xi. 20, is *not* Cantraine's species, though very near.) *Hab.* Atlantic, East and West, and Mediterranean. (M. [as *E. nitida*], W.) Shore at Gorgulho rock E. of Funchal, Punta de São Lourenço. Not common.

119. *Eulima Jeffreysiana*, 1869, Brusina, Jour. de Conch. 1869, XVII. 245 (as *Leiostraca*); Gwyn Jeffreys, Lightn. & Porc. dredg., P. Z. S. 1884, p. 366, xxviii. 1. *Hab.* Mediterranean.—Gwyn Jeffreys says that McAndrew got it at the Canaries, Rochebrune from the Cape Verd Is.; and that Verrill identified it from New England. (Jn., W.) From Funchal to the island's east extremity. Not rare.

120. *Eulima microstoma*, 1869, Brusina, Jour. de Conch. XVII. 244; Monterosato, Enum. p. 35; Locard, Malac. Franç. p. 208; Kobelt, Prodromus, p. 115. *Hab.* Mediterranean. (W.) Punta de São Lourenço. 2 specimens.

121. *Eulima paivensis*, 1873, Watson, P. Z. S. p. 364, pl. xxxvi. 29; Tryon, Manual, VIII. 277, lix. 58. *Hab.* Madeira and the Selvagens. Not common; but both Mr. Lowe and I got a good many specimens.

122. *Eulima Philippii*, 1868, Weinkauff, Conch. Mittheil. II. 228; Philippi, Enumeratio, I. 158, & II. 130, ix. 10 (as *E. distorta*, but not of Defrance): Gwyn Jeffreys, B. C. IV. 205; & V. 214, lxxvii. 5. *Hab.* From the Lofotens to the Mediterranean and Canaries. (M., L., W.) Extremely common everywhere.—Locard, Prodrome, p. 205, gives *E. incurva*, Renier's name, priority, but that author's name-list confers no priority, and the changes rung on the name of this species create mere confusion in the midst of which no private rights of nomenclature avail. Names are for public profit, not for individual glorification.

123. *Eulima rhaphium*, 1897, Watson, *antea*, p. 258.

124. *Eulima sordida*, 1897, Watson, *antea*, p. 257.

125. *Eulima subulata*, 1802, Donovan, Brit. Shells, V. pl. clxxii.: Gwyn Jeffreys, B. C. IV. 208; & V. 215, lxxvii. 7. *Hab.* From Britain to the Mediterranean. (M., Jn., W.) Everywhere; common.

126. *Eulima trunca*, 1897, Watson, *antea*, p. 259.

Eulimella, see *Odostomia*.

127. *Fasciolaria armata*, 1854, A. Adams (as *Latirus*), P. Z. S. p. 314. no. 11; Watson, 'Challenger' Moll. p. 243, xiii. 1.

Hab. Madeira; Tenerife; N.W. Africa. (L., W.) Punta de S. Lourenço and Porto Santo. Not common.

128. *Fissurella græca*, 1767, Linné (as *Patella*), Syst. Nat. p. 1261: Gwyn Jeffreys, B. C. III. 266, vi. 4; & v. 200, lix. 5. *Hab.* From the Færoes to Mediterranean and Canaries. (M., L., N., Jn., W.) Everywhere; common.

129. *Fossarus ambiguus*, 1767, Linné (as *Helix*), Syst. Nat. p. 1251; Adanson, Sénégal, p. 173, xiii. 1; Philippi, Enumeratio, II. 147, xxv. 1. *Hab.* From Bay of Biscay to Mediterranean, Canaries, and St. Helena. (L., Jn., W.) Everywhere; common.

130. *Gastrochæna dubia*, 1777, Pennant (as *Mya*), Brit. Moll. IV. 82, xliv. 19: Gwyn Jeffreys, B. C. III. 91, iii. 5; & v. 193, li. 6. *Hab.* From the Brit. Channel to Mediterranean, Canaries, Mogador, and St. Helena. (M., L., Jn., W.) Punta de São Lourenço to 50 fms., Magdalena shore. Very rare.

131. *Haliotis tuberculata*, 1767, Linné, Syst. Nat. p. 1256: Gwyn Jeffreys, B. C. III. 279, vii. 1; & v. lx. 2. *Hab.* From the Channel to Mediterranean, Canaries, and Mogador. (M., L., N., W.) All along the coast; common.

Hemiaclis, see *Aclis*.

132. *Homalogyra atomus*, 1841, Philippi (as *Truncatella*) in Wiegm. Archiv, VII. pt. 1, p. 54, v. 4; Enum. II. 134, xxiv. 5: Gwyn Jeffreys, B. C. IV. 69, i. 5; & v. lxx. 2. *Hab.* From North Norway to Mediterranean. (Jn., W.) Everywhere; common.

133. *Homalogyra rota*, 1853, Forbes & Hanley (as *Skenea*), Brit. Moll. III. 160, lxxiii. 10 & lxxviii. 1, 2: Gwyn Jeffreys, B. C. IV. 71; & v. 209, lxx. 3. *Hab.* From North Scotland to Mediterranean. (W.) Everywhere; common.

Hydrobia confusa, v. Frauenfeld, erroneously identified as *Bythinia similis*, Drap., lives entirely in the freshwater runnels, quite remote from the sea.

134. *Ianthina communis*, 1822, Lamarck, An. s. Vert. VI. (2) 206: Gwyn Jeffreys, B. C. (as *I. rotundata*, Leach) IV. 186, iii. 1 & frontispiece; & v. 214, lxxvii. 1. *Hab.* Oceanic. (M., L., Jn., W.) From Funchal to East point and Porto Santo. Common.

135. *Ianthina exigua*, 1822, Lamarck, An. s. Vert. VI. (2) 206; Forbes & Hanley, Brit. Moll. II. 555, lxix. 8, 9; Sowerby,

Ill. Index, xii. 4. *Hab.* Ocean. (M., W.) From Funchal to East point. Rare.

136. *Ianthina pallida*, 1841 (?), Harvey in Thompson's Brit. Mar. Conch. p. 152, & Ann. & Mag. v. 96, ii. 2; Philippi, Enumeratio, II. 224, xxviii. 14; Forbes & Hanley, Brit. Moll. II. 553, lxix. 10, 11. *Hab.* Ocean.—This species is given by McAndrew, and by him alone, as from Madeira, and the specimens in his collection at the British Museum are correctly identified; but his collection at Cambridge, which is more to be trusted, has no specimens, unless, as the Rev. A. H. Cook suggests, 7 fine specimens of "*I. prolongata*, Madeira," in the McAndrew collection be so regarded.

137. *Jeffreysia glabra*, 1844, Alder (as *Rissoa* ?), Ann. & Mag. XIII. 325, viii. 1–4: Gwyn Jeffreys, B. C. (as *Jeffreysia diaphana*) IV. 59, i. 3; & V. lxix. 5. *Hab.* Shetland to the Mediterranean. (W.) Funchal to East point and Porto Santo. Common.

138. *Jeffreysia globularis*, 1853, Gwyn Jeffreys in Forb. & Hanl. Brit. Moll. IV. 268, cxxxiii. 5: Gwyn Jeffreys, B. C. IV. 62; & V. lxix. 7. *Hab.* Scotland. (W.) Funchal to East point of Island. Rare.

139. *Jeffreysia opalina*, 1849, Gwyn Jeffreys, Ann. & Mag. 2nd ser. II. 351; Forb. & Hanl. B. Moll. IV. 267, cxxxiii. 10 & M.M. 2: Gwyn Jeffreys, B. C. IV. 60; & V. 209, lxix. 6. *Hab.* From Shetland to Mediterranean. (W.) From Funchal to East point and Porto Santo.

140. *Lachesis minima*, 1803, Montagu (as *Buccinum*), Test. Brit. p. 247, viii. 2: Gwyn Jeffreys, B. C. IV. 313, vi. 1; & V. 218, lxxxiv. 3. *Hab.* From Channel Islands to Mediterranean and Canaries. (M., L., Jn., W.) Everywhere; very common.

141. *Lamellaria perspicua*, 1767, Linné (as *Helix*), Syst. Nat. p. 1250: Gwyn Jeffreys, B. C. IV. 235, iii. 6; & V. 216, lxxix. 2. *Hab.* From Labrador to United States, and from Norway to Mediterranean and Canaries. (M., L., Jn., W.) Everywhere, but not common.

142. *Lasæa rubra*, 1803, Montagu (as *Cardium*), Test. Brit. p. 83, xxvii. 4: Gwyn Jeffreys, B. C. II. 219, v. 2; & V. 179, xxxii. 1. *Hab.* From Iceland to Mediterranean and Canaries. (M., L., Jn., W.) Everywhere; common.

Leda pygmæa, Münster.—I noticed this species in Mr. Yate Johnson's collection, but its presence there seemed to me accidental.

143. *Lima hians*, Gmelin (as *Ostrea*), Syst. Nat. p. 3332: Gwyn Jeffreys, B. C. II. 87, ii. 2ª; & v. 170, xxv. 5. *Hab.* From Northern Norway to the Mediterranean and Canaries. (M., N., Jn., W.) Everywhere; common.

144. *Lima squamosa*, 1818, Lamarck, An. s. Vert. VI. (1) 156; Sowerby, Thes. I. 84, xxi. 1 & 18 (?). *Hab.* Japan (*f.* Dunker); N. Zealand (*f.* v. Martens); Mediterranean. (M., L., N., Jn., W.) Everywhere; common.

145. *Lima subauriculata*, 1808, Montagu (as *Pecten*), Test. Brit. Suppl. p. 63, xxiv. 2: Gwyn Jeffreys, B. C. II. 82; & v. 169, xxv. 3. *Hab.* From N. America and Greenland to Mediterranean and Canaries. (L., Jn., W.) Everywhere; very common.

146. *Limacina bulimoides*, 1836, d'Orbigny (as *Atlanta*), Voy. Amér. Mérid. v. 179, xii. 36, 38; Souleyet, Rev. Zool. p. 138; Voy. 'Bonite,' II. 224, xiii. 35–42; Ptéropodes (as *Spirialis*), p. 65, xv. 3, 4; Woodward, Manual, p. 207, pl. xiv. 42; Pelseneer, 'Challenger' Report, p. 30. *Hab.* Pelagic. (W.) Everywhere; abundant.

147. *Limacina inflata*, 1836, d'Orbigny (as *Atlanta*), Voy. Am. Mérid. v. 174, xii. 16–19; Souleyet (as *Spirialis rostralis*), Ptérop. p. 62, xiv. 7–12; Pelseneer, 'Challenger' Report, p. 17. *Hab.* Pelagic. (Jn. "from 30 fms.," W.) Everywhere; very common.

148. *Limacina Lesueurii*, 1836, d'Orbigny (as *Atlanta*), Voy. Amér. Mérid. v. 177, xx. 12–15; Souleyet, Rev. Zool. 1840, p. 236, & Voy. 'Bonite,' II. 216, xiii. 11–16 (as *Spirialis ventricosa*); Pelseneer, 'Challenger' Report, p. 24. *Hab.* Pelagic. (Jn., W.) Everywhere; abundant.

149. *Limacina* (*Peracle*) *reticulata*, 1840, d'Orbigny, Voy. Amér. Mérid. v. 178, xii. 32–35, 39; Souleyet, Rev. Zool. 1840, p. 138, & Voy. 'Bonite,' II. 220, xiii. 17–19 (as *Spirialis clathrata*); Pelseneer, 'Challenger' Report, p. 34, pl. i. 7, 8. *Hab.* Pelagic. (W.) Funchal and Caniçal. 4 specimens.

150. *Limacina trochiformis*, 1840, d'Orbigny (as *Atlanta*), Voy. Amér. Mérid. v. 177, xii. 29–31; Souleyet, Rev. Zool. 1840, p. 237, & Voy. 'Bonite,' II. 223, xiii. 27–34 (as *Spirialis*); Pelseneer, 'Challenger' Report, p. 29. *Hab.* Pelagic. (W.) From Funchal, east coast. Not common.

Liriola, see *Siphonaria*.

151. *Litorina neritoïdes* 1767, Linné (as *Turbo*), Syst. Nat.

p. 1232: Gwyn Jeffreys, B. C. III. 361; & v. 206, lxv. 2. *Hab.* From Norway to Mediterranean and Canaries. (M., L., Jn., W.) All along the coast. Very common.

152. *Litorina punctata*, 1789, Gmelin, Syst. Nat. p. 3597; Adanson ("Le Marnat"), Sénégal, p. 168, pl. xii. 1; Philippi, Abb. & Beschr. II. 198, iv. 11. *Hab.* From the Mediterranean to Cape of Good Hope. (N., Jn., W.) I accept the species as Madeiran on the authority of Sen. Nobre. The specimens of Mr. Johnson and myself from the East end of the Island and from Porto Santo are too young and in too bad condition for independent recognition.

153. *Litorina striata*, 1831, King, Zool. Jour. v. 345. no. 51; d'Orbigny, Moll. Canar. (as *L. canariensis*) p. 78, vi. 8–10, & (*L. affinis*) p. 79, vi. 11–13.—the young tubercled shell. *Hab.* From Açores to St. Helena. (M., L., N., W.) Everywhere; very common.

154. *Lucina borealis*, 1767, Linné (as *Venus*), Syst. Nat. p. 1134: Gwyn Jeffreys, B. C. II. 242, v. 2; & v. 179, xxxii. 7. *Hab.* From America and Iceland to Mediterranean and Mogador. (L., Jn., W.) Funchal. Rare.

155. *Lucina divaricata*, 1767, Linné (as *Tellina*), Syst. Nat. p. 1120: Gwyn Jeffreys, B. C. (as *Loripes*) II. 235, v. 4; & v. 179, xxxii. 5. *Hab.* English Channel to Mediterranean and Canaries. (M., L., Jn., W.) Everywhere; very common.

156. *Lucina lactea*, 1767, Linné (as *Tellina*), Syst. Nat. p. 1119: Gwyn Jeffreys, B. C. (as *Loripes*) II. 233, v. 4; & v. 179, xxxii. 4. *Hab.* Southern Britain to Mediterranean and Canaries. (Jn., W.) Funchal. Very rare.

157. *Lucina reticulata*, 1791, Poli (as *Tellina*), Test. Sic. I. 48, xx. 12; Philippi, Enumeratio, I. 31, iii. 14. Everywhere; very common.

158. *Lucina spinifera*, 1803, Montagu (as *Venus*), Test. Brit. p. 577, xviii. 1: Gwyn Jeffreys, B. C. II. 240; & v. 179, xxxii. 6. *Hab.* From Norway to Mediterranean and Canaries. (M., L., N., Jn., W.) Everywhere; very common.

159. *Lyonsia norvegica*, 1788, Chemnitz (as *Mya*), Conch.-Cab. x. 345, clxx. 1647–8: Gwyn Jeffreys, B. C. II. 29, ii. 1; & v. 190, xlviii. 2. *Hab.* From Lofotens to Mediterranean. (M., L., Jn., W.) Everywhere; common.

160. *Mactra subtruncata*, 1778, da Costa, Brit. Conch. p. 198: Gwyn Jeffreys, B. C. II. 419; & v. 188, xliii. 3. *Hab.* From North Norway to Black Sea and Mogador. (Jn., W.) Porto

Santo, 40 to 50 fms. One stained valve.—The locality whence my specimen came is not a place where ballast is thrown out, and the presence of the species in Mr. Johnson's collection, as also at the Canaries and Mogador, compels me unwillingly to admit it as Madeiran. I do not believe, but cannot disprove.

Mangelia, see *Pleurotoma*.

161. *Marginella guancha*, 1839, d'Orbigny, Moll. Canaries, p. 88, vi. 32–34. *Hab.* Canaries. (Jn., W.) From the North coast.—McAndrew gives it as "frequent" in Madeira, but his specimens, both in his best collection at Cambridge and in that at the British Museum as well as those he sent me, are all marked as from "Canaries." The solitary specimen I got from Madeira was in sand from deep water on the north coast; probably, therefore, not a wanderer, but it remains solitary. In Mr. Johnson's collection also only one specimen presented itself.

162. *Marginella miliaria*, 1767, Linné (as *Voluta*), Syst. Nat. p. 1189; Sowerby, Thes. Conch. I. 399, lxxviii. 227–230. *Hab.* From Portugal to Mediterranean and Mogador. (M., L., Jn., W.) Everywhere; common.

M. Philippi (sic), a species given by Sen. Nobre as of Monterosato, who says that it is the *M. minuta*, Phil. Enum. II. 197, xxvii. 23 (but not of Pfeiffer), is one which I am quite unable to identify among any I know as Madeiran. *M. cælata*, which Monterosato gives in his 'Nomenclatura,' p. 139, as Madeiran from me, is a species I have been accustomed to reckon as *M. miliaria*, L., differing only in colour. Some confusion seems to exist here.

163. *Marginella secalina*, 1844, Philippi, Enumeratio, II. 197, xii. 15 & xxviii. 19; Weinkauff, Conch.-Cab. ed. 2, v. pt. 4, p. 29, iv. 21–23. *Hab.* Mediterranean to Canaries (*teste* McAndrew's List corrected *propria manu* and his specimens in the Cambridge Museum). (L., Jn., W.) From Funchal to Punta de São Lourenço. Plentiful.

164. *Mathilda quadricarinata*, 1814*, Brocchi (as *Turbo*), Conch. Foss. p. 375, vii. 6; Kobelt, Jahrb. I. 226, xi. 2. *Hab.* Western Mediterranean and St. Helena. (W.) Funchal, Punta de São Lourenço, and Porto Santo. Not rare.

Megathyris, see *Argiope*.

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* A five years' priority over the *Mathilda* of Semper has been claimed for the name *Cingulina* of Adams, but no sinistral-tipped shell can pass under Adams's definition. See 'Challenger' Gasteropoda, p. 499.

165. *Melampus exiguus*, 1832-4, Lowe, Zool. Journ. v. 291, xiii. 6, 7; Pfeiffer, Monog. Auric. Viv. p. 56; id. ibid. Suppl. p. 326; id. Auric. Mad., Malak. Blätter, 1866, p. 142; Paiva, Mal. Mad. p. 150. *Hab.* Madeira. (L., W.) North shore, Punta de São Lourenço; Selvagens. Rare.

166. *Mesodesma cornea*, 1791, Poli, Test. Sic. I. 73, & II. xix. 8 to 11. *Hab.* Mediterranean.—I give this species on the authority of Sen. Nobre, who got it in dredgings from Caniçal. I have never met with it.

Mesalia, see *Scalaria*.

167. *Mitra cornicula*, 1767, Linné (as *Voluta*), Syst. Nat. p. 1191; Kiener (as *M. lutescens*, Lam.), Iconog. Coq. Viv. III. 31, xi. 32, xii. 36, &c. *Hab.* Portugal and Mediterranean to Mogador. (M., L., N., Jn., W.) Everywhere; excessively common.

168. *Mitra Zebrina*, 1839, d'Orbigny, Moll. Canar. p. 86, vi. 29-31 (not *M. Zebra*, Leach); Sowerby, Thes. IV. 23, sp. 300, pl. xxii. 481. *Hab.* Canaries. (M., L., N., Jn., W.) Everywhere. Alive on the shore-rocks, and there dark green; but in deep water dead and discoloured brown by passage through fish's stomach. Extremely variable, with proclivities towards *M. tricolor*, Gd.

169. *Modiolaria discors*, 1767, Linné (as *Mytilus*), Syst. Nat. p. 1159: Gwyn Jeffreys, B. C. II. 126; & v. 171, xxviii. 3. *Hab.* From the U.S. coast to N. Greenland, Canada, Norway, and Mediterranean. (Jn., W.) One young valve alone in each collection. The range of the species alone justifies its introduction into this list.

170. *Modiolaria subclavata*, 1859, Libassi, Atti Panorm. III. 13. fig. 7; Gwyn Jeffreys, Moll. Lightn. & Porc., P. Z. S. 1879, p. 568. *Hab.* From Brittany to Canaries. (L., Jn., W.) From Magdalena, Cabo Girão, Funchal to East end of Island. Very abundant.

Monodonta, see *Trochus*.

171. *Montacuta bidentata*, 1803, Montagu (as *Mya*), Test. Brit. p. 44, xxvi. 5: Gwyn Jeffreys, B. C. II. 208; & v. 177, xxxi. 8. *Hab.* Norway to Mediterranean. (Jn., W.) Funchal. 15 to 20 valves.

172. *Montacuta ferruginosa* (?), 1808, Montagu (as *Mya*), Test. Brit. Suppl. I. pp. 22 & 166, xxvi. 2: Gwyn Jeffreys, B. C. II. 210; & v. 178, xxxi. 9. *Hab.* From New England to Greenland, North Norway, Mediterranean, Canaries, and Mogador. 3 fms. to 733 fms. (L., W.) Coast from

Funchal eastward, and Porto Santo. Very abundant.—McAndrew's List does not give the species, but in his own copy at the Cambridge Natural History Museum it is entered and initialled by himself for Madeira, Canaries, and Mogador. The query I have suffixed to the name expresses the grave doubts I feel, more than shared by Dr. Gwyn Jeffreys, of the correctness of this identification; but as he has taken the responsibility of publishing it as Madeiran on the strength of my specimens, I am content to follow him. With more reason than in many like cases elsewhere the shell might pass for new; but the species is a variable one.

173. *Montacuta triangularis*, 1897, Watson, *antea*, p. 264.

174. *Murex* (*Ocinebra*) *aciculatus*, 1822, Lamarck, An. s. Vert. VII. 176: Gwyn Jeffreys, B. C. IV. 310; & V. 218, lxxxiv. 2. *Hab.* From the English Channel to Mediterranean and Mogador. (M., L., Jn., W.) From Magdalena to island's East point and Porto Santo. Very abundant.

175. *Murex* (*Coralliophila*) *brevis*, 1832, de Blainville (as *Purpura*), Ann. Sc. Nat. I. 233, xi. 10; Philippi (as *Pyrula squamulata*), Enumeratio, I. 207, xi. 21 (not 31), II. 180. *Hab.* Mediterranean. (L., Jn., W.) Porto Santo. One specimen each.—Mr. Lowe has left no record of locality for his one very young specimen. In the face of confusion in the identification of this species I have unwillingly gone behind Philippi, whose figure and description are unmistakable.

Murex cristatus, Broc.—McAndrew, Report, p. 40, gives this as "rare;" for the Canaries he does not mention it: neither at Cambridge nor in the British Museum does his collection contain specimens, but Bellardi (vol. i. p. 87) gives it from Upper Miocene.

176. *Murex* (*Ocinebra*) *Edwardsii*, 1826, Payraudeau (as *Purpura*), Moll. Cors. p. 155, vii. 17, 18; de Blainville, Faune franç. p. 129, v. (B) 5. It exists from the Upper Miocene onwards. *Hab.* From Bay of Biscay to Mediterranean and Canaries. (M., L., N., Jn., W.) From Funchal westwards. Very abundant.

177. *Murex* (*Ocinebra*) *erinaceus*, 1767, Linné, Syst. Nat. p. 1216: Gwyn Jeffreys, B. C. IV. 306, V. 5; & V. 218, lxxxiv. 1. In existence from Middle Miocene onwards. *Hab.* From Cattegat to Black Sea and Mogador. (M., L., N., Jn., W.) From Funchal to East point and Porto Santo. Abundant.

Murex fusulus, see *Trophon*.

178. *Murex* (*Ocinebra*) *medicago*, 1897, Watson, *antea*, p. 242.

179. *Murex* (*Pseudomurex*) *Meyendorfii*, 1845, Calcara, Cenno, p. 38, iv. 32; Kobelt, Jahrb. Mal. Ges. I. 1874, p. 222, ix. 1. *Hab.* Mediterranean. (L., N., Jn., W.) From Funchal to East point and Porto Santo. Abundant.

Mytilus, see *Avicula*.

Mytilus edulis, L.—This is a species which Senhor Nobre gives under var. *M. galloprovincialis*. Johnson's collection contains two valves. I have several, chiefly young, but all got in circumstances and with the appearances of having been brought in ballast. Belonging to the North Pacific, probably, and under diverse forms and names from Baffin's Bay to the Mediterranean, its presence in Madeira is not improbable, but I am not sure that Senhor Nobre, on review of its claims, still supports them.

180. *Nassa antiquata*, 1897, Watson, *antea*, p. 241.

181. *Nassa costulata*, 1804, Renieri (as *Buccinum*), Tav. Conch. Adr.; Philippi (as *B. variabile*), Enum. I. 221, xii. 6; Payraudeau (as *B. Cuvieri*), Moll. Corse, p. 163, viii. 17, 18. *Hab.* From Portugal to Mediterranean. (L., Jn., W.) Everywhere; very common.

182. *Nassa incrassata*, 1777, Ström (as *Buccinum*), Norsk. Selskab. Vid. IV. 369, xvi. 25: Gwyn Jeffreys, B. C. IV. 351; & v. 219, lxxxviii. 1. *Hab.* From Iceland to Mediterranean and Mogador. (M., L., N., Jn., W.) Everywhere; very common.

183. *Nassa limata*, 1808, Chemnitz (as *Buccinum*), Conch.-Cab. XI. 87, clxxxviii. 1808–9; Philippi, Enumeratio (as *B. prismaticum*), I. 219; Brocchi (as *B. prismaticum*), Subappen. II. 337, v. 5–7. Dates from Upper Pliocene onwards. *Hab.* Mediterranean to Canaries. (M., L., N., Jn., W.) Everywhere; very common.

184. *Nassa reticulata*, 1767, Linné (as *Buccinum*), Syst. Nat. p. 1204: Gwyn Jeffreys, B. C. IV. 346, vi. 4; & v. lxxvii. 3. Dates from Lower Pliocene. *Hab.* From North Norway to Black Sea and Mogador. (L., Jn., W.) Porto Santo, Porto Moniz. Not common.

185. *Nassa Watsoni*, 1877, Kobelt, Iconog. europ. Meeres-conch. Heft 7, p. 151, xxvi. 5, 6. "Madeira," Canaries. *Hab.* The Selvagens (not in Madeira proper). At the Canaries it is common. (L., W.)

186. *Natica Dillwynii*, 1826, Payraudeau, Cat. Moll. Corse, p. 120, pl. v. ff. 27, 28; Philippi, Conch.-Cab. 2nd ed. II. pt. 1, p. 69,

pl. ii. f. 4. (L., Jn., W.) Punta de São Lourenço, Porto Santo, Punta da Cruz, Funchal, Gorgulho, &c. Abundant.

187. *Natica fanel*, 1843, Récluz, P. Z. S. p. 207; Philippi in Mart. & Chem. Conch.-Cab. 2nd ed. II. pt. 1, p. 16, ii. 7, 8 (not 6); Adanson, Sénégal, 1757, p. 174, xiii. 3 ("le Fanel"). *Hab.* Senegal. (L., Jn., W.) Punta de São Lourenço and Labra, also Porto Santo. Not common.

188. *Natica furva*, 1897, Watson, *antea*, p. 248.

189. *Natica porcellana*, 1839, d'Orbigny, Moll. Canar. p. 84, vi. 27, 28; Philippi in Mart. & Chem. Conch.-Cab. 2nd ed. II. pt. 1, p. 62, x. 4. *Hab.* Canaries to St. Helena. (M., L., Jn., W.) Everywhere, but nearly always dead, and lacking the operculum, which is thin, horny, and reddish.

190. *Natica variabilis*, Recluz, MS.; Reeve, Conch. Icon. IX. xxiii. 104; Philippi in Mart. & Chem. Conch.-Cab. 2nd ed. II. pl. xi. f. 3, as *N. labrella*, but not that of Lamarck, not the description on p. 68 nor fig. pl. xi. 17, nor pl. xix. f. 1; H. Adams, P. Z. S. 1869, p. 274, xix. 8 (as *N. marmorata*). *See* Watson, 'Challenger' Report, p. 435, for discussion of the species. *Hab.* Canaries. (L., Jn., W.) From the Gorgulho bay to Punta de São Lourenço, at the East point of the Island. Common.

Neæra, see *Cuspidaria*.

Ocinebra, see *Murex*.

191. *Octopus vulgaris*, 1798, Lamarck, Mém. Soc. Hist. Nat. Paris, vol. I. p. 18: Gwyn Jeffreys, B. C. v. 144, frontispiece & pl. vii. 1. *Hab.* West Indies, and from Scotland to Mediterranean and Canaries, and Indian Ocean, &c. (Jn., W.) Not rare.

192. *Odostomia acuta*, 1848, Gwyn Jeffreys, Ann. & Mag. 2nd ser. II. 338; id., B. C. IV. 130, & v. 211, lxxiii. 8. *Hab.* From Lofotens to Mediterranean. (Jn., W.) Along S. shore from Funchal eastwards and Porto Santo. Common.

193. *Odostomia albella*, 1846, Lovén, Ind. Moll. Scand. p. 19: Gwyn Jeffreys, B. C. IV. 121; & v. 211, lxxiii. 3. *Hab.* From Norway to Mediterranean. (L., Jn., W.) Funchal eastwards to East point. Very abundant.

194. *Odostomia* (*Turbonilla*) *bulinea*, 1840, Lowe, P. Z. S. p. 40; Brocchi, Conch. Foss. Subap. p. 383, vi. 7 (as *Turbo striatus*, but not that of Mont.). *Hab.* Mediterranean. (L. Jn., W.) Funchal to Punta de São Lourenço and Porto Santo.

Very abundant but always dead, the shell bored and the animal eaten.

195. *Odostomia* (*Turbonilla*) *clathrata*, 1848, Gwyn Jeffreys, Ann. & Mag. 2nd ser. II. 345; id. B. C. IV. 148, & V. 212, lxxiv. 9. *Hab.* From Portugal to Mediterranean; Ireland (?). (W.) Punta de São Lourenço. Not rare.—Dr. Gwyn Jeffreys says that McAndrew got it at Orotava in the Canaries; and if so it is probably the unnamed one in his Madeiran list, but I have no note of having seen it in his collection.

196. *Odostomia conoïdea*, 1814, Brocchi (as *Turbo*), Conch. Foss. Subap. 659, 2nd ed. vol. II. p. 495, xvi. 2: Gwyn Jeffreys, B. C. IV. 127; & V. 211, lxxiii. 6. *Hab.* From North Norway to Mediterranean. (Jn., W.) Funchal, Porto Santo. Not rare.

197. *Odostomia conspicua*, 1850, Alder, Trans. Tyne Club, I. 359: Gwyn Jeffreys, B. C. IV. 132; & V. 211, lxxiii. 9. *Hab.* From Lofotens to Mediterranean. (Jn., W.) Funchal to Punta de São Lourenço. Rare.

198. *Odostomia* (*Turbonilla*) *indistincta*, 1803, Montagu (as *Turbo*), Test. Brit. Suppl. p. 129: Gwyn Jeffreys, B. C. IV. 149; & V. 213, lxxv. 1. *Hab.* From Norway to Mediterranean and Canaries. (Jn., W.) Everywhere; common.

199. *Odostomia* (*Turbonilla*) *interstincta*, 1803, Montagu (as *Turbo*), Test. Brit. II. 324, xii. 10: Gwyn Jeffreys, B. C. IV. 151; & V. 219, lxxv. 12. *Hab.* From Lofotens to Mediterranean and Canaries. (M., L., Jn., W.) Everywhere; very common.

200. *Odostomia* (*Turbonilla*) *lactea*, 1767, Linné (as *Turbo*), Syst. Nat. p. 1238; Gwyn Jeffreys, B. C. IV. 164; & V. 213, lxxvi. 3. *Hab.* From Finmark to Mediterranean and Canaries. (M., L., W.) Everywhere; common.

201. *Odostomia* (*Turbonilla*) *nitidissima*, 1803, Montagu (as *Turbo*), Test. Brit. II. 299, xii. 1: Gwyn Jeffreys, B. C. IV. 173; & V. 214, lxxvi. 8. *Hab.* From Finmark to Mediterranean. (W.) Caniçal and Punta de São Lourenço and Porto Santo. Not rare.

202. *Odostomia omphaloessa*, 1897, Watson, *antea*, p. 261.

203. *Odostomia* (*Turbonilla*) *Pointeli*, 1867, de Folin, Fonds de Mer, p. 100, xi. 4; Monterosato, Nomenclatura (as *Anisocycla*), p. 99. *Hab.* Mediterranean. (W.) Caniçal, Punta de São Lourenço, Porto Santo. Not rare.

204. *Odostomia* (*Turbonilla*) *pusilla*, 1844, Philippi, Enumeratio, II. 224, xxviii. 21: Gwyn Jeffreys, B. C. IV. 167; & V. 213, lxxvi. 4. *Hab.* From English Channel to Mediterranean. (W.) Two specimens.

205. *Odostomia rissoïdes*, 1844, Hanley, P. Z. S. p. 18: Gwyn Jeffreys, B. C. IV. 122; & V. 211, lxxiii. 4. *Hab.* From Norway to Mediterranean. (W.) From the Gorgulho and Funchal to Punta de São Lourenço and Porto Santo. Very rare.

206. *Odostomia* (*Turbonilla*) *rufa*, 1836, Philippi (as *Melania*), Enumeratio, I. 156, ix. 7: Gwyn Jeffreys, B. C. IV. 162; & V. 212, lxxvi. 1. *Hab.* From Norway to Mediterranean and Canaries. (M., W.) Funchal to East point and Porto Santo. Not uncommon.

207. *Odostomia* (*Turbonilla*) *scalaris*, Philippi (as *Melania*), Enum. Moll. Sic. I. 157, ix. 9; & II. 137: (as *Chemnitzia*) Gwyn Jeffreys, B. C. IV. 160; & V. 213, lxxv. 7. *Hab.* From Massachusetts and New England to Finmark and the Mediterranean. (W.) Funchal, two broken specimens.

208. *Odostomia* (*Eulimella*) *scillæ*, 1836, Scacchi (as *Melania*), Notiz. Conchyl. p. 51: Gwyn Jeffreys, B. C. IV. 169; & V. 213, lxxvi. 5. *Hab.* From Finmark to Mediterranean and Canaries. (M., Jn., W.) One specimen alone fell to Mr. Johnson and one to myself.

209. *Odostomia tricincta*, 1856, Gwyn Jeffreys, Ann. & Mag. p. 185, ii. 12, 13. *Hab.* North-west of France to Mediterranean and Madeira. (W.) From Funchal to East point. Frequent.

210. *Odostomia turrita*, 1844, Hanley, P. Z. S. p. 18: Gwyn Jeffreys, B. C. IV. 135; & V. 211, lxxiv. 2. *Hab.* From the Cattegat to Mediterranean. (Jn., W.) Funchal to East point and Porto Santo. Common.

211. *Odostomia* (*Turbonilla*) *undata*, 1897, Watson, *antea*, p. 262.

212. *Odostomia unidentata*, 1803, Montagu (as *Turbo*), Test. Brit. III. 324, xxi. 2: Gwyn Jeffreys B. C. IV. 134; & V. 211, lxxiv. 1. *Hab.* From North Norway to Mediterranean. (W.) From Funchal to East point and Porto Santo. Common.

213. *Odostomia* (*Eulimella*) *ventricosa*, 1843, Forbes (as *Parthenia*), Brit. Assoc. Ægean Rep. p. 188; G. O. Sars, Moll. Arct. Norv. p. 209, xi. 19, & xxii. 16. *Hab.* From Norway to Mediterranean. (W.) One specimen.

214. *Oliva* (*Olivella*) *leucozonias*, 1839, Gray, Zool. of 'Blossom,'

p. 130, xxxvi. 24; Marrat, in Sowerby's Thesaurus, IV. sp. 213, pl. cccl. (bis) fig. 446. Neither of these authorities gives any habitat for the species. Weinkauff, who identifies it with *O. pulchella*, Duclos (see his Monog. pl. v. f. 11, 12), gives Senegal as its habitat. Not knowing it from Madeira, I quote it here simply as given "from Funchal" in Senhor Nobre's list, and with extreme hesitation.

Omalaxis, see *Bifrontia*.

215. *Ostrea cochlear*, 1795, Poli, Test. Sic. II. 179, xxviii. 28. *Hab.* From Bay of Biscay to Mediterranean. (Jn., W.) Funchal, &c. Common.

216. *Ostrea cristata*, 1780, Born, Mus. Cæs. p. 112, vii. 3; Poli, Test. Sic. II. 177, xxviii. 25–27. *Hab.* Mediterranean. (L., Jn., W.) Magdalena, Funchal, &c. Common.

217. *Ovula carnea*, 1789, J. L. M. Poiret (as *Bulla*), Voyage, II. p. 21; Bruguière, Encycl. III. 685, sp. 5, pl. ccclxvii. 2; Kiener, Icon. Coq. Viv. I. 10, vi. 2. *Hab.* Mediterranean. (W.) Magdalena. One specimen brought up from 100 fathoms in a jar accidentally entangled in a fisherman's line.

218. *Oxygyrus Keraudrenii*, 1817, Lesueur (as *Atlanta*), Jour. de Phys. LXXXV. 391, ii.; Woodward, Man. Moll. pl. xiv. 24, 25. *Hab.* Pelagic. (Jn., W.) From Funchal to East point, &c.

Panopæa, see *Saxicava*.

PATELLA.—The confusion both in the classification and nomenclature of this genus is very great. I touch on no disputed points when I state that no one at work on the shore of Madeira can doubt that there are four, and only four, very distinct and very easily differentiated species, and under the law of priority their names fall to them without difficulty. Alphabetically arranged they are:—

219. *Patella aspera*, 1819, Lamarck, An. s. Vert. VI. (1) 328; 2nd ed. by Deshayes, VII. 529; d'Orbigny, Moll. Canar. p. 98, vii. 9, 10 (as *P. Lowei*). [Hanley, see Wood, Ind. Test. p. 185, xxxvii. 19, says that this is Dillwyn's *P. repanda* of Gmel. Syst. Nat. ed. Linn. Syst. Nat. 13[a]; but both the locality "*freto Magellanico*," and the description "*testa tenui . . . . margine repando*," remove Gmelin's species very far from that found in Madeira. Dillwyn, indeed, ascribes Gmelin's *P. repanda* to "Island of Cerigo," but gives no authority for this assertion of Favanne.]

Hab. From the Bay of Biscay to Mediterranean and Canaries. (M., L., N., Jn., W.) Very common everywhere.

220. *Patella cærulea*, 1767, Linné, Syst. Nat. p. 1259 (*see* Hanley, Ips. Linn. Conch. p. 421); Philippi, Enum. I. 110, II. 84, vii. 5; Hidalgo, Moll. Mar. Esp. pl. l. 1–8, li. 1, 2; d'Orbigny (as *P. crenata*), Moll. Canar. p. 97, pl. vii. 1–8. *Hab.* Bay of Biscay to Mediterranean and Canaries. (M., L., N., Jn., W.) Very common everywhere.

221. *Patella rustica*, 1767, Linné, Syst. Nat. p. 1261; Wood (as *P. lusitanica*, Gmel., *see* Syst. Nat. p. 3715), Index Test. p. 188, pl. xxxvi. 66: Lamarck (as *P. punctata*), An. s. Vert. VI. (1) 333; ed. 2da Deshayes, VII. 537. no. 34; Delessert, pl. xxiii. 4; Reeve (as *P. nigropunctata*), Conch. Icon. pl. xxxiii. 57; d'Orbigny, Moll. Canar. p. 97, pl. vii B. 13–15. *Hab.* Bay of Biscay to Canaries. (M., L., N., Jn., W.) Very common everywhere.

222. *Patella vulgata*, 1767, Linné, Syst. Nat. p. 1258; d'Orbigny (as *P. Candei*), Moll. Canar. p. 98, pl. vii B. 11, 12: Gwyn Jeffreys (as *P. vulgata*), B. C. III. 236, v. 3; & v. lvii. 1–4. *Hab.* From north of Norway to Mediterranean and Canaries. (M., L., N., Jn., W.) Very common everywhere.

Patella Gussonii, see *Siphonaria*.

223. *Pecten corallinoïdes*, 1839, d'Orbigny, Moll. Canar. p. 102, pl. vii B. 20–22; Sowerby, Thes. Conch. I. 65, xii. 3, 4; Küster, in Mart. & Chemn. Conch.-Cab. 2nd ed. VII. pt. 2, p. 58, pl. xv. 7–9 (who denies the correctness of Sowerby's identification, which may however pass). *Hab.* Canaries and Madeira. (M., L., N., Jn., W.) Everywhere; very common.

224. *Pecten fenestratus*, 1843, Forbes, Brit. Assoc. Report, p. 192; Gwyn Jeffreys (as *Pleuronectia*), Med. Moll., Ann. & Mag. July 1870, p. 40, and (as *Amussium*) in Report on the Lightn. & Porc. Exped., P. Z. S. 1879, p. 561 (identifying Forbes' sp., however, with *Pecten Philippii*, Acton, Ricerche Conch. fig. 1 = *P. Actoni*, v. Martens, Malak. Blätter, 1857, p. 194, iii. 1–3, but mentioning at the same time some remarkable features of the species which made him hesitate in the identification). Kobelt, Prodromus, p. 440, extends this synonymy, and in his Monograph in the Conch.-Cab. 2nd ed. p. 268, pl. lxx. ff. 7, 8 (a copy of Acton's figure), quotes Verrill, Proc. U. S. Nat. Mus. 1880, p. 403, and also Trans. Connect. Acad. 1882, v. p. 582, for

this species as found on the East coast of America; but this identification Verrill (1884, Proc. Conn. Acad. VI. 261) now rejects. *Hab.* North Atlantic and Mediterranean. (Jn., W.) Punta de São Lourenço. Very rare.

225. *Pecten flexuosus*, 1795, Poli (as *Ostrea*), Test. Sicil. II. 159–161, xxviii. 1–3, and (as *O. plicata*) fig. 11; Philippi (as *P. polymorphus*), Enumeratio, I. 79, & II. 57, pl. v. 18–21. *Hab.* Mediterranean. (M., L., Jn., W.) Everywhere; common.

226. *Pecten Jacobæus*, 1767, Linné (as *Ostrea*), Syst. Nat. p. 1149; Pennant, Brit. Zool. IV. 100, xl. 1. *Hab.* Mediterranean to Canaries. (M., L., N., Jn., W.) Everywhere; common. —The *P. maximus* of McAndrew's collection in Cambridge, from the Canaries is a young specimen of *P. Jacobæus.* The same is probably the case in other instances.

227. *Pecten Loveni*, 1853, Dunker, Index Moll. Guin. p. 44. no. 115, ix. 31. *Hab.* The Guinea coast. (N.) Dunker got two separate valves from Loanda. Nobre, besides adding Sierra Leone, gives it as dredged in Funchal Bay.—The species is one I have never seen. Dunker's authority is of course of great weight; his figure, but less so his description, suggests the young form of *P. fenestratus*, Forbes.

228. *Pecten pes felis*, 1758, Linné (as *Ostrea*), Syst. Nat. ed. 10. vol. I. 697, & 1767, do. do. ed. 12. p. 1146; Sowerby, Thes. Conch. I. 67, xvii. 162, xx. 134. *Hab.* From Bay of Biscay to Mediterranean and Mogador. (M., L., N., Jn., W.) From Magdalena to Punta de São Lourenço. Not common, and the valves never joined.

229. *Pecten pusio*, 1767, Linné (as *Ostrea*), Syst. Nat. p. 1146: Gwyn Jeffreys, B. C. II. 51; & v. 166, xxii. 1. *Hab.* From Norway to Mediterranean and Cape of Good Hope. (M., L., N., Jn., W.) Everywhere; very abundant.

230. *Pecten similis*, 1811, Laskey, Mem. Werner. Soc. I. 387, viii. 8: Gwyn Jeffreys, B. C. II. 71; & v. 168, xxiii. 5. *Hab.* From Finmark to Mediterranean (and Jamaica, *f.* Barrett). (M., L., Jn., W.) Everywhere, from Magdalena to Punta de São Lourenço and Porto Santo. Very abundant.

231. *Pecten solidulus*, 1853, Reeve, Conch. Icon. VIII. pl. xxxiii. 155; Philippi (as *P. gibbus*, Lam.), Enumeratio, I. 83; Récluz (as *P. Philippi*, Michel.), Jour. de Conch. IV. 52, ii. 15; Monterosato, Coq. Maroc., Jour. de Conch. 1889,

p. 20. *Hab.* Mediterranean to Canaries. (M., L., N., Jn., W.) Everywhere; very abundant.—The Marquis of Monterosato has done a great service in showing that this species is not the *P. gibbus*, Lam., nor the fossil *P. Philippi*, Michelotti of 1839, and that his own name of *P. commutatus* for the species is later than Reeve's. After following him "*per tot discrimina*" *nominum*, we may hope that this unfortunate species will rest under Reeve's shelter.

232. *Pecten varius*, 1767, Linné (as *Ostrea*), Syst. Nat. p. 1146. *Hab.* From Norway to Mediterranean.—This species enters here as one given in Senhor Nobre's list, supported, however, by an entry in Mr. Lowe's List (Journ. Linn. Soc. 1860, p. 173) of shells observed at Mogador in which *Pecten varius* occurs. Mr. Lowe's own copy, however, of that paper, along with the three separate valves sent him from Mogador, is in my possession, and a note appended by himself states that he had not found the species, but received it along with fourteen others (and probably several more, see *l. c.* p. 172) "from Mrs. Elton."

233. *Pectunculus glycimeris*, 1767, Linné (as *Arca*), Syst. Nat. p. 1143: Gwyn Jeffreys, B. C. II. 166, iv. 4; & v. 175, xxx. 2. *Hab.* From the Lofotens to Mediterranean, Mogador, and Canaries. (M., L., N., Jn., W.) Funchal, Labra, Punta de São Lourenço, Porto Santo. Abundant.

Pectunculus siculus, 1843, Reeve, Conch. Icon. vol. i. Monog. 5, pl. vii. fig. 41.—McAndrew alone gives this species (a syn. of *P. bimaculatus*, Poli), and he has added to it "frequent," but no one else has found it. In the British Museum shells ticketed "*P. siculus*, presented by Mr. McAndrew," are marked "Canarian." The locality whence the Cambridge Museum specimens belonging to his own more special collection were derived is not noted, but the name attached indicates that he held the species to be distinct from *Pecten glycimeris*.

234. *Pedipes afra*, 1790, Gmelin (as *Helix*), Syst. Nat. p. 3795. no. 194; Lowe, Zool. Jour. v. 296, xiii. 8–12, and P. Z. S. 1854, p. 217 (note under *Truncatella*), & p. 218; Deshayes, Lamarck, An. s. Vert. 2nd ed. IX. 42; Pfeiffer, Monog. Auric. I. 68; H. & A. Adams, Genera, III. pl. lxxxiii. 4, 4[a]. The whole credit of this species really belongs to Adanson (Hist. Sénégal, p. 11, pl. i. 4), who carefully, minutely, and most accurately described and figured the animal and the shell under the name of "Le piéton—Pedipes." *Hab.* From Lisbon (*see* Wollaston, Test. Atlant. pp. 50, 265, 293) to Senegal and St. Helena. (Jn., W.) Very common

under stones and large shingle between high- and low-water mark.

Peplidea, see *Plocamophorus*.

235. *Phasianella pulla*, 1767, Linné (as *Turbo*), p. 1233: Gwyn Jeffreys, B. C. III. 338, viii. 1; & v. 204, lxiv. 1. *Hab.* From Great Britain to Mediterranean, Mogador and Canaries. (M., L., N., Jn., W.) Everywhere; very common.

236. *Philine aperta*, 1767, Linné (as *Bulla*), Syst. Nat. p. 1183: Gwyn Jeffreys, B. C. IV. 457, viii. 7; & v. xcvi. 1. *Hab.* From North Norway to Mediterranean and Cape of Good Hope. (M., L., Jn., W.) Everywhere; common.

237. *Philine complanata*, 1897, Watson, *antea*, p. 235.

238. *Philine desmotis*, 1897, Watson, *antea*, p. 236.

239. *Philine scabra*, 1776, Müller (as *Bulla*), Zool. Dan. Prod. II. 41, lxxi. 11, 12; Wood, Crag Moll., Gasterop. p. 181, xxi. 12 (as *Bulla*); Philippi, Enum. I. 121, vii. 17 (as *Bulla angustata*); Forbes & Hanley, Brit. Moll. III. 543, cxiv E. 4, 5: Gwyn Jeffreys, B. C. IV. 447; & v. 224, xcvi. 1; G. Sars, Moll. Norv. p. 294, xviii. 13. *Hab.* From Greenland to Mediterranean. Fossil in English Coralline Crag and the older glacial clay beds of Norway. (W.) Funchal, 50 fms. —I think it just possible that my specimens may belong to Müller's species (which finds representation under somewhat diverse figures), and cannot take the responsibility of describing the Madeira species as new on the strength of merely two specimens, obviously of one species, but of which one is little more than embryonic and the other is slightly chipped. At the same time I greatly doubt whether they can be left under this name: their spire is too high, the corner of the outer lip droops too far below the plane of the apex, and the sculpture is too fine, too uniform, and too sparse to suit Müller's species.

240. *Philine trachyostraca*, 1897, Watson, *antea*, p. 236.

241. *Pinna rudis*, 1767, Linné, Syst. Nat. p. 1159: Gwyn Jeffreys, B. C. IV. 99, frontispiece & iii. 1; & v. 170, xxvi. *Hab.* From Great Britain to Mediterranean and Canaries. (M., L., Jn., W.) Everywhere; common.

242. *Pleurobranchus Dautzenbergi*, 1897, Watson, *antea*, p. 239.

243. *Pleurobranchus Lowei*, 1897, Watson, *antea*, p. 240.

244. *Pleurobranchus plumula*, 1803, Montagu, Test. Brit. I. 214, xv. 9, vignette ii. 5; Gwyn Jeffreys, B. C. v. 11, xcvii. 4. *Hab.* From Bohuslän, Sweden, to the Ægean. (Jn., W.)—

This species is poorly represented by two small rather damaged shells and a somewhat broken but well-grown specimen whose dorsal margin-line is straighter than usual, and in that respect resembles *P. brevifrons*, Phil., which, however (*f.* Monterosato), cannot reckon as a species.

245. *Pleurotoma* (*Mangelia*) *anceps*, 1830, Eichwald, Naturhist. Skiz. Lithauen &c. p. 225: Gwyn Jeffreys, B. C. (as *Defrancia teres*) IV. 362, & V. 219, lxxxviii. 5. *Hab.* From Lofotens to Mediterranean and Canaries. (M., Jn., W.) Funchal, Punta de São Lourenço, 30 to 40 fms. Not common.

246. *Pleurotoma* (*Mangelia*) *gracilis*, 1803, Montagu (as *Murex*), Test. Brit. p. 267, xv. 5; Gwyn Jeffreys, B. C. IV. 363, V. 219, lxxxviii. 6. *Hab.* Gt. Britain to Mediterranean and Canaries. (M., L., N., Jn., W.) From Magdalena to Punta de São Lourenço. Common.

247. *Pleurotoma* (*Clathurella*) *histrix*, 1832, Cristofori & Jan, Catalogus Conch. Foss. p. 10; Gwyn Jeffreys, Ann. & Mag. Nat. Hist. ser. 4, VI. 82; Brugnone, Pleur. Foss. Palerm. p. 28, i. 21; Bellardi, Moll. Terz. Piemonte, vol. II. 266; Monterosato, Enumeratio, p. 46. *Hab.* Mediterranean. (Jn., W.) Funchal, Punta de São Lourenço. Very abundant.

248. *Pleurotoma* (*Mangelia*) *incrassata*, 1837, Dujardin, Mém. Tour. p. 292, xx. 28; Philippi, Enumeratio, II. 168, xxvi. 6. *Hab.* Mediterranean. (Jn., W.) Funchal, Punta de São Lourenço. Rare.

249. *Pleurotoma* (*Clathurella*) *Leufroyi*, 1828, Michaud, Bull. Soc. Linn. Bord. II. 121, i. 5, 6; Gwyn Jeffreys, B. C. IV. 366; & V. 219, lxxxix. 1. *Hab.* From Norway to Mediterranean and Canaries. (Jn., W.) Funchal, Punta de São Lourenço, Porto Santo. Very abundant.

250. *Pleurotoma* (*Clathurella*) *linearis*, 1803, Montagu (as *Murex*), Test. Brit. I. 261, ix. 4: Gwyn Jeffreys, B. C. IV. 368, vii. 1; & V. 220, lxxxix. 2. *Hab.* From Iceland and Northern Norway to Mediterranean and the Canaries, (M., L., W.) From Funchal to Punta de São Lourenço and Porto Santo. Very abundant.

251. *Pleurotoma* (*Mangelia*) *nebula*, 1803, Montagu (as *Murex*), Test. Brit. p. 267, xv. 6 · Jeffreys, B. C. IV. 384; & V. 220, xci. 1. *Hab.* From North Norway to Mediterranean and

Canaries. (M., L., N., Jn., W.) Everywhere; very abundant. Mr. Johnson mentions having got it from 30 fms.

252. *Pleurotoma* (*Clathurella*) *purpurea*, 1803, Montagu (as *Murex*), Test. Brit. p. 260, ix. 3: Gwyn Jeffreys, B. C. IV. 373; & v. 220, lxxxix. 5, 6. *Hab.* From Gt. Britain to Mediterranean and Canaries. (M., L., W.) Everywhere; abundant.

253. *Pleurotoma* (*Clathurella*) *reticulata*, 1804, Renieri (as *Murex*), Tav. Alfab. p. 2: Gwyn Jeffreys, B. C. IV. 370, & v. 220, lxxxix. 3, 4. *Hab.* From Norway to Mediterranean. Everywhere; common.

254. *Pleurotoma* (*Mangelia*) *rugulosa*, 1844, Philippi, Enumeratio, II. 169, xxvi. 8: Gwyn Jeffreys, B. C. IV. 381; & v. 220, xc. 4. *Hab.* S.W. England to Mediterranean. (L., Jn., W.) Very abundant.—This is the species which Monterosato (Nomenclatura, p. 130) identifies as *Mangelia Stosiciana*, Brus., Jour. de Conch. 1869, p. 235.

255. *Pleurotoma* (*Mangelia*) *septangularis*, 1803, Montagu (as *Murex*), Test. Brit. p. 260, ix. 5: Gwyn Jeffreys, B. C. IV. 390; & v. 222, cxi. 5. *Hab.* From South Norway to Madeira and Canaries. (M., L., Jn., W.) Everywhere; very abundant.

256. *Pleurotoma* (*Mangelia*) *striolata*, 1836, Scacchi, Catalogus, p. 12; Philippi, Enumeratio, II. 168, xxvi. 7: Gwyn Jeffreys, B. C. IV. 376; & v. 220, xc. 1. *Hab.* From Norway to Mediterranean and Canaries. (M., L., N., Jn., W.) Everywhere; extremely abundant. Johnson mentions having got it in 30 fms.

257. *Pleurotoma* (*Mangelia*) *Vauquelini*, 1826, Payraudeau, Moll. Corse, p. 145, vii. 14, 15; Kiener, Iconog. vol. v. Pleurot. p. 76, xxvi. 2; Weinkauff, Conch. Mittelm. II. 166; Kobelt, Prodrom. Moll. Mar. Europ. p. 141. *Hab.* Mediterranean. (M., L., Jn., W.) Everywhere; abundant.

Poromya granulata.—This species, as represented by a single valve, appears in McAndrew's List, p. 37, but it is not to be found in his collection either at the British Museum or at Cambridge, and no one else has met with it in Madeira.

258. *Plocamophorus maderæ*, 1842, Lowe (as *Peplidea*), P. Z. S. p. 51. (L.) Gorgulho Bay.

259. *Psammobia costulata*, 1822, Turton (as *Tellina*), Conch. Dic. p. 87, vi. 8: Gwyn Jeffreys, B. C. II. 394; & v. 187, xlii. 2.

Hab. From Norway to Mediterranean and Canaries. (M., L., W.) Everywhere; very common.

260. *Psammobia ferroensis*, 1782, Chemnitz (as *Tellina*), Conch.-Cab. VI. 99, x. 91: Gwyn Jeffreys, B. C. II. 396; & v. xlii. 3. *Hab.* From Iceland to Mediterranean and Canaries, and fossil from the later Italian Tertiaries. (N.) Senhor Nobre alone has been fortunate enough to secure this species: "Dredged at Caniçal."

Pseudomurex, see *Murex*.

261. *Purpura hæmastoma*, 1767, Linné (as *Buccinum*), Syst. Nat. p. 1202; Philippi, Enumeratio, I. 218, & II. 187, xxvii. 2. Mediterranean to Senegal (see Adanson, as *Purpura Sakem*, p. 100, vii. 1), Cape de Verdes (Bowditch, p. 242), Lagos (E. A. Smith, P. Z. S. 1871, p. 732). (L., N., Jn., W.) Everywhere; very common.

Pyrula, see *Murex*.

262. *Ranella* (*Aspa*) *marginata*, 1788, Gmelin (as *Buccinum*), Syst. Nat. p. 3486. no. 63; Martini (as *Utriculus fimbriatus-dentatus*), Conch.-Cab. III. 425, pl. cxx. 1101–2; Sowerby, Genera, II. pl. cciii. f. 2; Kiener (as *R. lævigata*), Iconog. VII. p. 34, xiii. 2; Deshayes (*R. lævigata*), Encycl. III. 882; Lamarck (*R. lævigata*), An. s. Vert. VII. 154, 2nd edit. (Deshayes) IX. 550; Küster (*R. lævigata*), Conch.-Cab. 2nd edit., III. pt. 2, p. 154, xxxix *a*. 8; Hörnes (*R. lævigata*), Foss. Moll. Wien. Bass. I. 214, xxi. 7–11; Seguenza (*R. marginata*), Formazioni Terz. p. 108. *Hab.* Canaries and N.W. Africa, but best known as a fossil. (L., W.) Funchal, Porto Santo. Living, but rather rare.

263. *Ranella reticularis*, 1780, Born (as *Murex*), Mus. Vind. p. 300, pl. xi, 5; Lamarck (as *R. gigantea*), An. s. Vert. VII. 150, 2nd ed. (Deshayes) IX. 540; Reeve, Conch. Icon. vol. II. sp. 3; Philippi, Enumeratio, I. 211, & II. 183. *Hab.* From Bay of Biscay to Mediterranean. (L., N., Jn., W.) Porto Santo, Funchal. Rare.—This is *Murex olearium* of Linné's 10th, but not of his 12th edition.

264. *Ranella scrobiculator*, 1767, Linné (as *Murex*), Syst. Nat. p. 1218; Adanson, Sénégal (as "Jabik"), p. 121, pl. viii. 13; Deshayes (as *Triton*), Encycl. III. 1056, pl. ccccxiv. 3; d'Orbigny (as *R. abbreviata*), Moll. Canar. p. 94. *Hab.* Mediterranean to Senegal. (L., N., Jn., W.) From Gorgulho Bay to Punta de São Lourenço. Abundant.

265. *Ranella Thomæ*, 1853, d'Orbigny, Moll. Cuba, II. 164, xxiii. 23. *Hab.* Island of St. Thomas, W. Indies. (Jn., W.) Punta de São Lourenço and Porto Santo; 5 full-grown (3 living) and 4 young shells. There are 2 specimens in the Brit. Mus. from the Cape Verd Is.—I have failed to trace this species to 1846, to which year d'Orbigny ascribes it. It does not occur in his Amér. Méridion. For note on the species, see Watson, 'Challenger' Report, p. 400.

266. *Ringicula auriculata*, 1811, Ménard (as *Marginella*), Ann. Mus. XVII. 331; Philippi, Enumeratio, I. 231, II. 198, xxviii. 13; Morelet, Jour. de Conch. 1878, p. 275, v. 14; Watson, Jour. de Conch. 1878, p. 312, x. 4. *Hab.* Bay of Biscay to Mediterranean. (M., L., N., Jn., W.) Everywhere; extremely abundant.

267. *Ringicula Someri*, 1867–71, de Folin, Fonds d. l. Mer, I. pt. 1, p. 14, i. 7; Morelet, Monog. Ringicula, Jour. de Conch. 1878, p. 128, v. 8. *Hab.* Cape Verd Is. (N.)—I give this species entirely on the authority of Senhor Nobre. It is one I have not seen, and of which I cannot judge. Among the very great number of specimens of *Ringicula* collected in Madeira I have never seen any variety on which to found a species, and indeed the peculiarities obvious in the figures of *R. Someri* are exactly those of the immature shell of *R. auriculata.*

268. *Rissoa* (*Onoba*) *abjecta*, 1873, Watson, Mad. Moll., P. Z. S. p. 385, xxxvi. 23; Weinkauff, Conch.-Cab. 2nd ed. I. pt. 22, p. 164, xx. 15. *Hab.* Madeira. (W.) Funchal. One specimen, now lost.

269. *Rissoa* (*Cingula*) *albugo*, 1873, Watson, P. Z. S. p. 379, xxxv. 17; Wienkauff, Conch.-Cab. 2nd ed. I. pt. 22, p. 150, xviii. 9. (Jn., W.) Everywhere; abundant.

270. *Rissoa* (*Alvania*) *aurantiaca*, 1873, Watson, P. Z. S. p. 367, xxxiv. 3; Weinkauff, Conch.-Cab. 2nd ed. I. pt. 22, p. 145, xviii. 1. (Jn., W.) Everywhere abundant.—The *R. aurantiaca* of Brusina is (*f.* Monterosato) *Barleeia rubra*, Mont.

271. *Rissoa* (*Cingula*) *callosa*, 1868, Manzoni, Jour. de Conch. pp. 166 & 214, x. 3; Weinkauff, Conch.-Cab. 2nd ed. I. pt. 22, p. 153, xviii. 14, 15. (Jn., W.) Funchal eastwards to Punta de São Lourenço and at Porto Santo. From 30 fms. upwards to the shore.—The identification of this species is

that of Mr. McAndrew. He was kind enough to send me specimens of Manzoni's species, but they were too much rubbed to render independent estimate possible. The figures of the species in the 'Journal de Conchyliologie' (*l. c.*) are not good, and as reproduced in the 'Conchylien-Cabinet' (*l. c.*) and in Tryon's 'Manual' (IX. 350, lxv. 6) have still less character.

272. *Rissoa* (*Alvania*) *canariensis*, 1839, d'Orbigny, Moll. Canar. p. 78, vi. 5–7; Watson, P. Z. S. 1873, p. 376, xxxv. 13; Weinkauff, Conch.-Cab. 2nd ed. I. pt. 22, p. 118, iii. 19, 20. *Hab.* Mediterranean to Canaries. (L., Jn., W.) Everywhere; very abundant. Semifossil in the Caniçal beds.

273. *Rissoa* (*Alvania*) *cancellata*, 1778, da Costa (as *Turbo*), Brit. Conch. p. 104, viii. 6–9: Gwyn Jeffreys, B. C. IV. 8; & V. 207, lxiv. 3; Watson, P. Z. S. 1873, p. 367, xxxiv. 2. *Hab.* From Gt. Britain to Mediterranean, Mogador, and Canaries. (M., L., N., Jn., W.) Everywhere; very abundant.

274. *Rissoa coriacea*, 1868, Manzoni, Jour. de Conch. pp. 166 & 242, x. 6; Watson, P. Z. S. 1873, p. 369, xxxvi. 27; Weinkauff, Conch.-Cab. 2nd ed. I. pt. 22, p. 141, xvi. 11. *Hab.* Mediterranean. (Jn., W.) From Funchal to Punta de São Lourenço, in 30 to 50 fms. Not common.

275. *Rissoa* (*Alvania*) *costata*, 1796, John Adams (as *Turbo*), Trans. Linn. Soc. III. 65, xiii. 13, 14: Gwyn Jeffreys, B. C. IV. 22; & V. 207, lxviii. 2; Watson, P. Z. S. 1873, p. 369, xxxiv. 5. *Hab.* From Norway to Mediterranean and Canaries. (Jn., W.) Everywhere; abundant.

276. *Rissoa* (*Alvania*) *costulata*, 1844, Alder, Ann. & Mag. vol. XIII. p. 324, viii. 8, 9; Gwyn Jeffreys, B. C. IV. 35; & V. 208, lxviii. 1; Watson, P. Z. S. 1873, p. 378, xxxv. 15. *Hab.* From Gt. Britain to Mediterranean. (L., Jn., W.) Everywhere; very abundant.

277. *Rissoa* (*Alvania*) *crispa*, 1873, Watson, P. Z. S. p. 369, xxxiv. 6; Weinkauff, Conch.-Cab. 2nd ed. I. pt. 22, p. 157, xix. 9, 10. (Jn., W.) From Funchal to Punta de São Lourenço and Porto Santo. Abundant.

278. *Rissoa* (*Cingilla*) *cristallinula*, 1868, Manzoni, Jour. de Conch. p. 5, x. 2; Weinkauff, Conch.-Cab. 2nd ed. I. pt. 22, p. 153, xviii. 13, 16. *Hab.* Canaries. (W.) Porto Santo. Two specimens.

279. *Rissoa* (*Cingula*) *depicta*, 1868, Manzoni, Jour. de Conch. p. 168, x. 4; Watson, P. Z. S. 1873, p. 382, xxxv. 20; Weinkauff, Conch.-Cab. 2nd ed. I. pt. 22, p. 152, xviii. 12. *Hab.* Canaries and Madeira. (Jn., W.) From Funchal to Punta de São Lourenço. Abundant.—This Madeiran species is quite obviously distinct from *R. semistriata*, Mont., and from *R. Galvagnæ*, Arad.; probably it is distinct from Manzoni's species and would be better called *R. punctifera*, as the Monog. of 1873 (*l. c.*) suggests, but satisfactory specimens of Manzoni's Canarian *R. depicta* are wanting for present revision. I leave it therefore as given in the P. Z. S. of 1873.

280. *Rissoa* (*Alvania*) *euchila*, 1886, Watson, P. Z. S. 1873, p. 377, pl. xxxv. 13 (as *R. novarensis*, but not that of von Frauenfeld as stated on the authority of Baron Schwarz v. Mohrenstern; the error was corrected in the 'Challenger' Report, and frequently since); Weinkauff, Conch.-Cab. 2nd ed. I. pt. 22, p. 147, xviii. 14. (Jn., W.) From Funchal to Punta de São Lourenço, at various depths. Abundant.

281. *Rissoa* (*Crossea*) *gibbera*, 1873, Watson, P. Z. S. p. 371, xxxiv. 7; Weinkauff, Conch.-Cab. 2nd ed, I. pt. 22, p. 158, xix. 11, 12. (Jn., W.) From Funchal to Punta de São Lourenço and Porto Santo. Abundant.—I do not believe this species to be a *Rissoa*, and doubt the claim of *Crossea* to be there admitted; but with entire ignorance o the animal, it is better *quieta non movere*.

282. *Rissoa* (*Pisinna*) *glabrata*, 1824, von Mühlfeldt (as *Helix*), Verhand. naturhist. Gesellsch. I. 218, iii. 10; Philippi (as *R. punctulum*), Enumeratio, I. 154, x. 11, & II. 130; Watson, P. Z. S. 1873, p. 386, xxxvi. 24. *Hab.* From Bay of Biscay to Mediterranean and Canaries. (L., Jn., W.) From Funchal to Punta de São Lourenço. Abundant.

283. *Rissoa* (*Cingula*) *innominata*, 1897, Watson (1873 as *R. concinna*, Monterosato), P. Z. S. 1873, p. 381, xxxv. 19. (Jn., W.) Everywhere; abundant.—There is difficulty over both the differentiation and the name of this species. In 1869 the Marquis of Monterosato published a Mediterranean species as *R. concinna* (see Test. Nuov. Sicil. p. 8. no. 2). In 1875 (Nuov. Revista, p. 26) he ranked it as a var. of *R. Galvagni*, Arad.; but in 1878 (Enumerazione &c. p. 26) restored it to specific rank, but marked that the name

of *R. concinna* he had given it was preoccupied by Searles Wood for a different species; and in that belief in his 'Nomenclatura,' 1884, p. 66, he changed the name of his Mediterranean species to *R. beniamina*. But *R. concinna* was a mere catalogue-name which Searles Wood, when he came for the first time to describe the species, replaced by a true specific name, viz. *R. punctura*. *R. concinna* thus remains as the name of Monterosato's Mediterranean species. That name therefore I should have adopted here for the Madeiran species now in view but for the fact that Monterosato rejects my identification of the Madeiran species with his from the Mediterranean. The material for a thorough independent opinion I do not possess, and I am content to accept the judgment of an authority in every way so trustworthy—compelled, however, in these circumstances to propose for the Madeiran species the new name I have given above.

284. *Rissoa* (*Alvania*) *Leacocki*, 1873, Watson, P. Z. S. p. 367, xxxiv. 1; Weinkauff, Conch.-Cab. 2nd ed. I. pt. 22, p. 157, xix. 8. (L., Jn., W.) Gorgulho shore, Punta de São Lourenço down to 45 fms., Porto Santo to 50 fms., Selvagens. Abundant.

285. *Rissoa* (*Pisinna*) *lincta*, 1873, Watson, P. Z. S. p. 387, xxxvi. 26; Tryon, Manual of Conch. IX. 341, lxix. 47. *Hab.* Madeira, Canaries. (W.) Funchal and Santa Cruz. Five specimens from Madeira, one from Tenerife.

286. *Rissoa* (*Alvania*) *Macandrewi*, 1868, Manzoni, Jour. de Conch. pp. 164 & 237, x. 1; Watson, P. Z. S. 1873, p. 372, xxxiv. 8; Weinkauff, Conch.-Cab. 2nd ed. I. pt. 22, p. 159, xix. 13–15. (Jn., W.) Funchal, Cruz Point. Very abundant.

287. *Rissoa* (*Onoba*) *Moniziana*, 1873, Watson, P. Z. S. p. 373, xxxiv. 10; Weinkauff, Conch.-Cab. 2nd ed. I. pt. 22, p. 146, xviii. 2, 3. (Jn., W.) From Funchal to Punta de São Lourenço and Porto Santo. Abundant.

Rissoa (*Alvania*) *Montagui*, 1826, Payraudeau, Moll. Corse.—One specimen which I got in Funchal Bay, 50 fms., the ordinary anchorage and discharge for ballast, is, so far as I know, the only representative of this species found in Madeira; and I stated in P. Z. S. 1873, p. 390, that I did not on such evidence regard it as Madeiran. Weinkauff, however (Conch.-Cab. 2nd ed. I. pt. 22, p. 114), gives it as Madeiran, but without quoting any authority. It ought not without further evidence to reckon as Madeiran.

Rissoa parva, 1778, da Costa (as *Turbo*), Brit. Conch. (W.) Funchal, 50 fms. Two rubbed and broken specimens, doubtless not Madeiran, but brought in ballast.

288. *Rissoa* (*Cingilla*) *picta*, 1867, Gwyn Jeffreys, Ann. & Mag. p. 435; Watson, P. Z. S. 1873, p. 381, xxxv. 18; Weinkauff, Conch.-Cab. 2nd ed. I. pt. 22, p. 151, xviii. 10. (L., Jn., W.) Everywhere in shallow water. Very abundant.

Rissoa (*Setia*) *pulcherrima*, Gwyn Jeffreys; Watson, P. Z. S. 1873, p. 383, is now suppressed.

289. *Rissoa* (*Pisinna*) *sabulum*, 1842, Cantraine, Bull. Acad. Brux. IX. pt. 2, p. 348; Watson, P. Z. S. 1873, p. 387, xxxvi. 25. *Hab.* Mediterranean. (L., Jn., W.) In shallow water from Funchal to Punta de São Lourenço, Porto Santo, and the Selvagens. Abundant, but local. —It seems strange that both this species and *R. glabrata*, v. Mühl., should be identified with *R. punctulum*, Phil.

290. *Rissoa similis*, 1836, Scacchi, Cat. Reg. Neap. p. 14; Watson, P. Z. S. 1873, p. 379, xxxiv. 16, 16*a* (given then, as now, in utter disbelief in the whole group into which *R. parva* has been split, but given here because work such as Baron Schwarz v. Mohrenstern's great Monograph on the group cannot without impertinence be gainsaid except by work of equal fulness and care. The species, as well as the others of the group, is given here from his identification of specimens from Madeira). Mediterranean. (L., Jn., W.) Everywhere, including the Selvagens. Very abundant.

291. *Rissoa* (*Setia*) *spadix*, Watson, P. Z. S. 1873, p. 383, xxxvi. 22 (as *R. perminima*, Manzoni).—Weinkauff, Conch.-Cab. 2nd ed. I. pt. 22, p. 149, quotes my paper &c. under *R. perminima*, Manzoni, whose description he follows, but his figure 8, pl. xviii., is a copy of the Madeiran species now published (see Reeve, Conch. Icon. as, on my suggestion (*l. c.*), distinct); that is, the description refers to a different species from that of the figure. I adopted in the P. Z. S. paper of 1873 Dr. Gwyn Jeffreys's identification of my Madeiran species. I am still, as then, unfortunately without any specimens of Manzoni's Canarian species; but on fresh and very careful review I am satisfied that Manzoni's description will not cover the Madeiran species, and Mr. Edgar A. Smith's opinion confirmatory of my own is adverse to Dr. Jeffreys's identification.—(Jn., W.) From Funchal to Punta de São Lourenço and Porto Santo. Not abundant.

292. *Rissoa* (*Alvania*) *spreta*, 1873, Watson, P. Z. S. p. 373, xxxiv. 9. (Jn., W.) Santa Cruz, Machico, Labra, Punta de São Lourenço, Porto Santo; 20 to 50 fms. Excessively abundant.—This species was named, described, and figured as a possible variety of *R. Macandrewi*, but that opinion is really not tenable.

293. *Rissoa* (*Onoba*) *striata*, 1797–1800, John Adams (as *Turbo*), Tr. Linn. Soc. III. 66, xiii. 25, 26: Gwyn Jeffreys, B. C. IV. 37; & v. 208, lxviii. 2; Watson, P. Z. S. 1873, p. 368 (the var. *lirata*, Wats. *l. c.* pl. xxxiv. fig. 3). (Jn., W.) Everywhere, but never abundant.

294. *Rissoa* (?) *tenuisculpta*, 1873, Watson, P. Z. S. p. 389, xxxv. 28; Weinkauff, Conch.-Cab. 2nd ed. I. pt. 22, p. 148, xviii. 6, 7. *Hab.* From Bay of Biscay to Mediterranean, in very deep water. (W.) Funchal, Punta de São Lourenço. Very rare.

295. *Rissoa violacea*, 1814, Desmarest, Bull. Soc. Phil. p. 8, pl. i. 8; Watson, P. Z. S. 1873, p. 378, xxxv. 14; Weinkauff, Conch.-Cab. 2nd ed. I. pt. 22, p. 110, ii. 17–19, xvii. 4–6. *Hab.* From Norway to Mediterranean and Canaries. (M., Jn., W.) Porto Santo. There alone, but in abundance. —By a slip of the pen McAndrew gives this species both for the Canaries and for Madeira as *R. purpurea*.

296. *Rissoa Watsoni*, 1873, Schwarz v. Mohrenstern *in litt.*; Watson, P. Z. S. 1873, p. 375, pl. xxxv. fig. 11; Weinkauff, Conch.-Cab. 2nd ed. I. pt. 22, p. 174, xxii. 10, 11. (Jn., W.) Everywhere; abundant.

Roxaniella, see *Atys*.

297. *Saxicava* (*Saxicavella*) *carinata*, 1811, Brocchi (as *Mytilus*), Conch. Foss. Subappen. 1st ed. p. 585, & 2nd ed. II. 406, xiv. 16; Searles Wood, Crag Moll. II. 289, xxix. 5 *a–e*. *Hab.* Mediterranean, but existing from the later Tertiary period. (Jn., W.) Funchal, Cruz Point. Very local, but not rare.

298. *Saxicava* (*Saxicavella*) *plicata*, 1809, Montagu (as *Mytilus*), Test. Brit., Suppl. p. 70: Gwyn Jeffreys, B. C. III. 75, iii. 2; & v. li. 1 (as *Panopæa*). *Hab.* From the Shetlands to the Mediterranean. (L., Jn., W.) Everywhere; very abundant.

299. *Saxicava rugosa*, 1767, Linné (as *Mytilus*), Syst. Nat. p. 1156: Gwyn Jeffreys, B. C. III. 81, iii. 3; & v. 192, li. 3.

Hab. Nearly all seas. (M., L., Jn., W.) Everywhere; very abundant.

300. *Scalaria aspera*, 1897, Watson, *antea*, p. 251.

301. *Scalaria clathratula*, 1798, G. Adams, Micr. xiv. 19: Gwyn Jeffreys, B. C. IV. 96; & V. 210, lxxi. 5.—McAndrew gives this species from the Canaries, but not as, Dr. Jeffreys (*cf. ref.*) says, from Madeira, nor does any other collector seem to have found it. I got only ten young specimens from deepish water at five stations along the South-east coast from Funchal to Punta de São Lourenço and from Porto Santo.

302. *Scalaria cochlea*, 1844, G. B. Sowerby, Thes. Conch. I. pt. 4, p. 103 bis, xxxv. 142; Dunker, Moll. Guinea, p. 18, ii. 46–48. (M., L., Jn., W.) Paül do Mar, Funchal; Punta de São Lourenço; Porto Santo. Rare.

303. *Scalaria communis*, 1819, Lamarck, An. s. Vert. VI. 2nd pt. p. 225; Deshayes, Encycl. Méthod. III. 951, pl. ccccli. 3; Gwyn Jeffreys, B. C. IV. 91, ii. 3; & V. lxxi. 3. *Hab.* From North Norway to the Mediterranean and the Canaries. (N., W.) Two bought specimens; having these, and considering the distribution of the species, I give it here on the authority of Senhor Nobre.

304. *Scalaria commutata*, 1877, Monterosato, Ann. Mus. Genov. IX. 420; Kiener, Coq. Viv. IX. pt. 2, pl. iii. 9 (as *S. monocycla*, but not that of Lamarck); Philippi, Enum. I. 167, x. 2, II. 145 (as *S. pseudoscalaris*, but not that of Brocchi); Sowerby, Thes. I. pt. 4, p. 101, xxxvi. 131, 132, 134 (as *S. clathrus*, but not of Linné). *Hab.* From Normandy to Mediterranean. (L., N., Jn., W.) Porto da Cruz, Porto Santo. Neither common nor abundant.—The separation of this species from *S. pseudoscalaris*, Broc., is hardly justified by the absence of spines at the top of the longitudinal ribs; there is an indication, though weak, of such a development in the Madeiran form.

305. *Scalaria Fischeri*, 1897, Watson, *antea*, p. 252.

306. *Scalaria formosissima*, 1884, Jeffreys, 'Lightning' and 'Porcupine' Moll., P. Z. S. p. 140, x. 10; Dautzenberg, Moll. Açores Dragages 'Hirondelle,' p. 56; Tryon, Man. Conch. IX. 62, xvii. 34. *Hab.* Porcupine Bank and Açores; North Atlantic, 340 to 1514 fms. (L.) Two specimens, without record of locality.

307. *Scalaria frondosa*, 1829, J. Sow. Min. Conch. VI. 149, dlxxvii. 1; Searles Wood, Crag Moll. I. 92, viii. 15; Tiberi (as *S. soluta*), Jour. de Conch. 1863, p. 159, vi. 3, & 1868, p. 84, v. 2.—I got this species in from 10 to 50 fms. on the whole S.E. coast of Madeira, from Funchal to Punta de São Lourenço, and also from Porto Santo; but the specimens were few and were all young shells. It did not occur in any other collection.

Shell pure ivory-white, glossy, hunchy, that is very broad in proportion to height, with well-rounded rather depressed whorls, a broad very fine pointed spire, distant strongish oblique ribs spiralled, without an umbilicus. *Sculpture*—*Longitudinals*: each whorl is obliquely crossed by about 14 strongish but not thick, projecting reverted ribs, which with a very marked sinistral twist run continuously from whorl to whorl down the spire; each rib runs out near the suture into a well-marked but generally bluntish tooth; besides the ribs the whole surface is finely scored, not roughened, by striæ, strong at the base of each rib. *Spirals*: the whole polished surface of the shell, including, but more faintly, the ribs themselves, is marked somewhat feebly by flatly rounded spiral threads, which, somewhat crowded on the earlier whorls, are on the later whorls parted by interspaces about as broad as the threads. *Colour* ivory-white, but a little translucent. *Whorls* probably 6 or 6½, but of full-grown shells only fragments presented themselves—the largest as measured below has 4½, exclusive of those of the embryo. *Suture* somewhat oblique, deeply impressed. *Apex* a very perfect small sharp cone of 4 complete whorls which are barely convex, with a linear suture: they are polished but microscopically cancellated by longitudinal and spiral scratches. *Mouth* a very little elliptical, rather small. *Outer lip* broadly expanded into a thin lamina, which is continued all round, leaving a kind of furrow, but no chink between it and the body-whorl. L. 0·21. B. 0·11.

I have described this species because the existing descriptions are so vague that identification is extremely difficult, as is proved by the ten synonyms quoted by Jeffreys, P. Z. S. 1884, p. 136. My own identification is somewhat of a guess, but if wrong can be checked from

the description and from the presence of the living form; and the presence of the species not only in the Mediterranean but in 547 fms. out in the Atlantic "off Madeira" (see Jeffreys, as quoted above) may justify what is at least better than the addition of still one other erroneous synonym.

308. *Scalaria* (*Cirsostrema*) *hellenica*, 1843, Forbes, Ægean Invert., Brit. Assoc. Rep. p. 189; Philippi (as *Rissoa coronata*), Enum. Moll. Sic. II. 172, xxiii. 7. *Hab.* Mediterranean. (Jn., W.) Funchal, Punta de São Lourenço, Porto Santo. Rather rare.—Dr. Gwyn Jeffreys quotes Hörnes as authority for this as a fossil of the Vienna basin; but I doubt the identification.

309. *Scalaria pulchella*, 1832, Bivona, Nuov. Moll. p. 11, i. 3; Philippi, Enumeratio, I. 158, x. 1; & II. 145. *Hab.* Mediterranean. (W.) Funchal, Santa Cruz, Caniçal. Rare, but fragments and young shells common.

310. *Scalaria rhips*, 1897, Watson, *antea*, p. 250.

311. *Scalaria Schulzii* (1868, but then the name alone was given by Weinkauff). 1844, Philippi (Zeits. Malakol. p. 108) gave this species, in error, as *S. multistriata*, Say. This error of identification on the part of Philippi, Weinkauff (after further error in the Jour. de Conch. 1862, p. 348) corrected in his Conch. d. Mittelm. 1868, vol. II. 239. *Hab.* Mediterranean. (Jn., W.) Funchal, Punta de São Lourenço, Porto Santo. Not rare.—I here give this species on the authority of Dr. Gwyn Jeffreys. I feel doubtful of the identification, but have not material for an independent opinion on the Madeiran form.

312. *Scalaria Smithii*, 1897, Watson, *antea*, p. 253.

313. *Scalaria* (*Acirsa*) *subdecussata*, 1835, Cantraine, Bull. Acad. Brux. vol. II. 388; do. Malac. Médit. pl. vi. 24. *Hab.* Mediterranean to Madeira. (M., L., Jn., W.) From Magdalena to Punta de São Lourenço and Porto Santo. Not abundant.

314. *Scalaria Turtonæ*, 1819, Turton (as *T. Turtonis*), Conch. Dic. p. 208, xxvii. 97: Gwyn Jeffreys, B. C. IV. 8, 9; & V. lxxi. 2. *Hab.* From Scotland to Mediterranean (not Norway). (M., L., Jn., W.) From Funchal to Punta de São Lourenço and Porto Santo, but not abundant.

315. *Scaphander* (*Weinkauffia*) *diaphana*, 1839, Aradas and

Maggiore (as *Bulla*), Cat. Conch. Sicil. p. 40; Forbes (as *Bulla turgidula*), Ægean Invert., Brit. Assoc. Rept. 1843, p. 188; Gwyn Jeffreys (as *Scaphander gibbulus*), Ann. & Mag. Feb. 1856, Mar. Tert. Piedm. p. 188, pl. ii. 20, 21; Vayssière (as *Weinkauffia diaphana*), Jour. de Conch. 1893, p. 90, iv. 1–8. *Hab.* Mediterranean. (W.) From Funchal to Punta de São Lourenço and Porto Santo. Rather rare.

316. *Schismope depressa*, 1897, Watson, *antea*, p. 263.

317. *Sepia officinalis*, 1767, Linné, Syst. Nat. p. 1095; Gwyn Jeffreys, B. C. v. 138, vi. 3. *Hab.* From Norway to Mediterranean. (Jn., W.) Rare.

318. *Siphonaria* (*Liriola*) *Gussonii*, 1829, O. G. Costa (as *Ancylus*), Oss. Is. Pant. &c. p. 20. no. 25; Philippi (as *Patella pellucida*), I. p. 111, vii. 7, & (as *P. Gussonii*) p. 255; & vol. II. p. 84. *Cf.* Dall, Jour. de Conch. 1878, p. 68, & 1879, p. 285, with many other valuable references given by the Marquis of Monterosato in his 'Nomenclatura,' p. 150. *Hab.* California, West Indies, and Mediterranean. (M., L., Jn., W.) Everywhere abundant.

319. *Skenea planorbis*, 1780, Fabricius (as *Turbo*), Faun. Grönl. p. 384: Gwyn Jeffreys, B. C. IV. 65, i. 4; & v. 202, lxx. 1. *Hab.* From Spitzbergen to Greenland and Florida and to the Mediterranean. (Jn., W.) All along the S.E. shore and Porto Santo. Very abundant.

320. *Solarium Architæ*, 1830, O. G. Costa, Cat. Test. Taranto, Acad. Sc. III. 40, & Fauna Napoli, p. 5, i. 1; Monterosato, Notiz. Solar. Medit. p. 10, figs. 21–23. *Hab.* From Bay of Biscay to St. Helena and Mediterranean. (Jn., W.) Funchal. Very rare.

321. *Solarium fallaciosum*, 1872, Tiberi, Bull. Mal. Ital. v. 35; Monterosato, Solarii Medit. p. 8, figs. 12–20. (= *Sol. siculum*, Cantr., probably, and to *S. stramineum*, auct. *nec* Lam.) *Hab.* Mediterranean. (Jn., W.) Very rare.—McAndrew's List gives this sp. (as *S. stramineum*) for Vigo, but not for Madeira, nor for the Canaries; and represented so poorly as are both this species and the preceding one, they must be held as a little doubtfully indigenous to Madeira.

322. *Solarium hybridum*, 1767, Linné (as *Trochus*), Syst. Nat. p. 1228; Lamarck, An. s. Vert. VII. 4; & 2nd ed. IX. 99; Philippi, Enumeratio (as *S. luteum*), I. 74, x. 127; Monterosato, Solarii Medit. p. 7, figs. 10, 11. *Hab.* Mediterranean

and St. Helena. (Jn., W.) Funchal to Punta de São Lourenço and Porto Santo.—Hanley (Ips. Lin. Conch. p. 315), whose opinion I forsake with extreme reluctance, so uniformly is he wise and right, regards Linné's *S. hybridum* as the "New Holland" species, which, though like, is quite distinct; but when Linné says expressly for *S. hybridum*, "habitat in mare Mediterraneo," the other identification, even though it were by Linné himself, must be dropped.

323. *Solarium mediterraneum*, 1872, Monterosato, Notiz. Foss. Mte. Pellegrino &c. p. 31, but without description, which followed in 1873, in Solar. Med. p. 6, figs. 8, 9. *Hab.* Mediterranean. (L., Jn., W.) Magdalena from 100 fms., living; Funchal; Labra. Rare.—This is the *S. simplex* of Tiberi, but not of Brown, which is a Pliocene fossil not found living in the Mediterranean. It is the *S. pseudoperspectivum* of Philippi but not of Brocchi, which also is a Pliocene fossil not now alive in the Mediterranean. It is the *S. sulcatum* of Costa but not of Lamarck, which (*teste* Defrance) is a Grignon fossil = *S. patulum*, Lam. It is the *S. pulchellum* of Tiberi but not of Michelotti (*see* Trans. Royal Soc. Edin. xv. pt. 1, p. 215), a Miocene fossil. When one so endowed as Hörnes (Foss. Moll. Wien, I. 464), corroborated by the opinion of one possessing the opportunities and abilities of Monterosato, and followed by so capable a judge as Sacco (Moll. terz. Piemonte &c. pt. 12, p. 48), pronounces a definite judgment on this *Solarium* as being distinct from *S. pseudoperspectivum* of Brocchi, it would be an impertinence for an ordinary observer to set up an opposite opinion; but the two species have very much in common.

324. *Solecurtus antiquatus*, 1799, Pulteney (as *Solen*), Cat. Dors. p. 28, iv. 5; Gwyn Jeffreys, B. C. III. 6, i. 1; & v. 190, xlvi. 2. *Hab.* From Great Britain to the Mediterranean and Canaries. (M., L., Jn., W.) Everywhere: abundant. Johnson's specimens got at Funchal came from 30 fms.

325. *Solecurtus candidus*, 1804, Renieri (as *Solen*), Tav. Alf. Conch. Adr. p. 1: Gwyn Jeffreys, B. C. III. 3; & v. 190, xlvi. 1. *Hab.* From Shetland to the Mediterranean and Canaries. (M., L., Jn., W.) Not abundant, but found everywhere.

326. *Solemya togata*, 1793, Poli (as *Tellina*), Test. Sicil. II. 42, xv. 20; Philippi, Enumeratio, I. 15, i. 17; & II. 12 (as

Solenomya mediterranea, Lam.). *Hab.* From the Lusitanian coast to Mediterranean and Canaries. (W.) A fragment of a full-grown living specimen and some very young shells; but there are in the British Museum Madeiran specimens of McAndrew's dredging not enumerated in his List.

Spirialis, see *Limacina* and *Peraclis*.

327. *Spirula Peronii*, 1822, Lamarck, An. s. Vert. VII. 601; & 2nd ed. by Deshayes, XI. 280; Woodward, Manual, pp. 13 & 77, pl. i. 9. *Hab.* Oceanic. (L., W.) Caniçal, Porto Santo.—Linné (Syst. Nat. p. 279) called the species *Nautilus spirula*. By a mistake on their respective plates, but corrected in the text by both authors, de Blainville (Manuel de Mal. p. 381, pl. iv. 1 *a*, *b*) and Deshayes (Encyclop. Méthod. III. 975, pl. ccccLxv. 5) introduced a good deal of confusion by calling the species *S. australis*.

328. *Spondylus Powellii*, 1892, E. A. Smith, Journal of Conchol. vol. VII. p. 70; McAndrew, Brit. Assoc. Rept. 1850 *passim* as *S. gædaropus*. *Hab.* From Madeira to Cape Verd. (M., L., N., W.) Funchal, Punta de São Lourenço.—I assume that McAndrew and Nobre refer to this species under the name *S. gædaropus*, as certainly did both Mr. Lowe and myself till Mr. Smith brought better counsel.

Tectura, see *Acmæa*.

329. *Tellina balaustina*, 1767, Linné, Syst. Nat. p. 1119: Gwyn Jeffreys, B. C. II. 371; & v. 186, xl. 3. *Hab.* From Shetland to Canaries. (M., L., Jn., W.) From Magdalena to Punta de São Lourenço. Very abundant.

330. *Tellina balthica*, 1767, Linné, Syst. Nat. p. 1120: Gwyn Jeffreys, B. C. II. 375, vii. 3; & v. 186, xl. 5. *Hab.* From Japan, Behring Sts., and N.W. America to Massachusetts; the Black Sea and Mogador. (W.) Porto Santo. Very rare and really admissible only on the ground of its distribution, my Madeiran acquaintance with it extending only to one valve.

331. *Tellina* (*Oudardia*) *compressa*, 1814, Brocchi, Conch. Foss. Subappen. II. 323, xii. 9; Hörnes, Foss. Moll. Wien, II. 89, xiii. 6; Cantraine, Bull. Acad. Brux. 1835, II. 398 (as *T. Brocchii*). *Hab.* N.W. coast of Africa. (L., N., Jn., W.) Everywhere; very abundant.

332. *Tellina donacina*, 1767, Linné, Syst. Nat. p. 1118: Gwyn Jeffreys, B. C. II. 386; & v. 187, xli. 4. *Hab.* Shetland to

Mediterranean and Canaries. (M., L., N. Jn., W.) Very abundant everywhere. Johnson, from 30 fms., I from 100 fms.

333. *Tellina fabula*, 1781, Gronovius, Zoophyl. III. 263, xviii. 9: Gwyn Jeffreys, B. C. II. 382; & v. 186, xli. 2. *Hab.* From North Norway to Black Sea and Cape of Good Hope. (Jn., W.) Porto Santo. Rare. At Mogador it is very common.

334. *Tellina incarnata*, 1767, Linné, Syst. Nat. p. 1118; Hanley, Ipsa Linn. Conch. p. 39: Gwyn Jeffreys (as *T. squalida*, Pult.), B. C. II. 384, xli. 3. *Hab.* From Scotland to Mediterranean and Canaries. (M., L., N., Jn., W.) Everywhere; abundant.—This is the *T. incarnata* of Linné, Poli, Forbes & Hanley, and Römer, but not of Born nor Chemnitz nor Schröter &c.

Tellina serrata, 1814, Brocchi, Conch. Foss. Subappen. p. 510, xii. 1; Römer, Conch.-Cab. 2nd ed. x. pt. 4, p. 39, xii. 1–4. A species published by Senr. Nobre as Madeiran, but got there by no one else, would be entitled on the score of its distribution (from Portugal to Mediterranean, Canaries, and Mogador) to a place here had Senr. Nobre either got it himself or supplied information regarding it; but an exceptional species merely forwarded by a friend as "dredged at Funchal" really lacks certification.—I have just learned at the last moment from Canon Norman that he dredged this species in Madeira this spring.

335. *Tellina tenuis*, 1778, da Costa, Brit. Conch. p. 210: Gwyn Jeffreys, B. C. II. 379; & v. 186, xli. 1. *Hab.* From North Norway to Mediterranean, the Black Sea, and Mogador. (Jn., W.) Machico and Porto Santo. Not rare, but very local.

336. *Teredo bipennata*, 1819, Turton, Conch. Dic. p. 184, figs. 38–40; Forbes and Hanley, Brit. Moll. I. 80, i. 9–11: Gwyn Jeffreys, B. C. III. 182; & v. 194. *Hab.* From the Færoes to Mediterranean, also Vancouver Island and California. (L., Jn., W.) From Punta Delgada to Punta de São Lourenço and met with in floating timber.

337. *Teredo Dallii*, 1897, Watson, *antea*, p. 266.

338. *Teredo malleolus*, 1819, Turton, Conch. Dic. p. 255; also Dithyr. Brit. pl. ii. 19; Forbes & Hanley, Brit. Moll. I. 84, i. 12–14: Gwyn Jeffreys, B. C. III. 181; & v. 194. *Hab.* From W. Indies to Western Europe. (W.) Funchal, Porto Santo.

339. *Teredo megotara*, 1853, Hanley, in Forb. & Hanl. Brit. Moll. I. 77, i. 6, xviii. 1, 2: Gwyn Jeffreys, B. C. III. 176; & v.

194, liv. 4. *Hab.* North Atlantic on both sides from Spitzbergen and Greenland southward. (L., Jn., W.) From the Gorgulho and the Desertas (Bugio) to Punta de São Lourenço and Porto Santo.

340. *Teredo Stutchburii*, 1828, de Blainville, Dic. Scien. Nat. III. 268; G. B. Sowerby, Thes. Conch. v. 124, sp. 18, pl. ccccIxix. 8; Fischer, Jour. de Conch. 1856, p. 255. *Hab.* Sumatra (*f.* Fischer, but it does not appear in v. Martens's &c. List). (W.) From Funchal to Punta de São Lourenço. Not common.

341. *Thracia papyracea*, 1791, Poli (as *Tellina*), Test. Sic. I. 43, xv. 14 & 18: Gwyn Jeffreys, B. C. III. 36, ii. 2; & v. 191, xlviii. 4, 4a. *Hab.* From Iceland to Mediterranean and Canaries. (M., L., Jn., W.) From Magdalena (100 fms.) to Punta de São Lourenço and Porto Santo. Not abundant.

342. *Thracia pubescens*, 1799, Pulteney (as *Mya*), Cat. Dors. p. 27, iv. 6: Gwyn Jeffreys, B. C. III. 38; & v. 191, xlviii. 5. *Hab.* From English Channel to Mediterranean. (L., Jn., W.) From Funchal to Punta de São Lourenço. Not abundant.

Tornatina, see *Utriculus*.

343. *Triforis perversa*, 1767, Linné (as *Trochus*), Syst. Nat. p. 1231; Gwyn Jeffreys, B. C. (as *Cerithium*), IV. 261; & v. 217, lxxx. 5. *Hab.* From Norway to Mediterranean, the Canaries, Mogador, St. Helena, and California (*teste* E. A. Smith). (M., L., Jn., W.) Everywhere; enormously abundant.

Triptera, see *Cuvieria*.

344. *Triton chlorostoma*, 1822, Lamarck, An. s. Vert. VII. 185; & ed. 2, Desh. IX. 636; Quoy & Gaim. Astrol. II. 541, xl. 16, 17; Kiener, Iconog. vol. VIII. p. 19, xii. 2; Reeve, Icon. vol. II. viii. 25; Kobelt, Conch.-Cab. 2nd ed. III. pt. 2, p. 161, xlii. 1, 2, 5, 6; Tryon, Manual, III. 13, vii. 47, 48. *Hab.* Red Sea (?); Isle de Bourbon (*teste* Deshayes and also Quoy & Gaimard); New Caledonia (?); Philippines (?); Central Pacific (?); Sandwich Islands (?); West Indies, Bermuda (*teste* Tristram). [*Note.*—Of these localities, two at least besides Madeira are trustworthy and establish a very remarkable habitat.] (L., Jn., W.) Paül do Mar, Magdalena (100 fms.), Punta de São Lourenço. Not common.

345. *Triton corrugatus*, 1822, Lamarck, An. s. Vert. VII. 181 & 2nd ed. Desh. IX. 628; Deshayes, Encycl. Méthod. III.

1056, ccccxvi. 3 *a*, *b*; Kiener, Iconog. vol. VIII. p. 14, viii. 1; Reeve, Iconog. II. pl. v. 15. *Hab.* From the Bay of Biscay to Mediterranean and Grand Canary. (L., N., Jn., W.) From Funchal to Punta de São Lourenço and Porto Santo. Not rare.

346. *Triton cutaceus*, 1767, Linné (as *Murex*), Syst. Nat. p. 1217: Gwyn Jeffreys, B. C. IV. 303, v. 4; & v. 218, lxxxiii. 4. *Hab.* From English Channel to Mediterranean, Mogador, and Canaries. (W.) Funchal, Porto Santo. Rare.

347. *Triton nodifer*, 1822, Lamarck, An. s. Vert. VII. 178; & 2nd ed. Desh. IX. 624: Gwyn Jeffreys, B. C. IV. 301; & v. 218, lxxxiii. 3. *Hab.* From English Channel to Mediterranean. (L., N., W.) Funchal and eastwards. Not uncommon.

348. *Triton olearium*, 1767, Linné (as *Murex*), Syst. Nat. ed. 12 (*not* ed. 10), p. 1216; Adanson (Le "Vojet"), Sénégal, p. 118, viii. 12; Chemnitz, Conch.-Cab. (as *Buccinum quinquangulare*), IV. 96, 97, cxxxi. 1052, 1053, 1054, 1056, and also XI. 115, cxci. 1837–8; Deshayes (as *T. succinctus*), Encycl. Méthod. III. 1057, ccccxvi. 2; also in Lamarck, An. s. Vert. 2nd ed. IX. 628; Kiener, Iconog. (as *T succinctus*), vol. VIII. 33, vi. 1; Reeve (*T. olearium*), Conch. Icon. II. Monog. pl. ix. 32. *Hab.* South America, Cuba, Mediterranean, Cape of Good Hope, Australia, New Zealand, Japan, and the Pacific; but v. Martens does not give it in the Indian Ocean. (M., L., N., Jn., W.) Funchal to Punta de São Lourenço. One specimen from Porto Santo presents the exact features of *T. martinianum*, d'Orb., from the West Indies. Not uncommon. [*Note.*—The *T. olearium* (*Murex*) of Linné's 10th ed. = *Ranella gigantea*, Lam., is *Murex reticularis*, Born.]

349. *Triton reticulatus*, 1826, de Blainville, Faun. franç. p. 118, iv. D. 5; Kiener, Iconog. VIII. 26, xviii. 3; Reeve, Conch. Icon. II. xvii. 72; Kobelt, Conch.-Cab. 2nd ed. III. pt. 2, p. 237, lxv. 6, 7: Philippi, Enumeratio (as *Ranella lanceolata*), I. 211; & II. 183, xi. 28. *Hab.* Mediterranean and Senegal. (L.) One specimen dredged in Labra. Very doubtful.

350. *Triton tritonis*, 1767, Linné (as *Murex*), Syst. Nat. p. 1222; Born (as *Murex*), Index Mus. p. 315; Chemnitz (as *Buccinum*), Conch.-Cab. IV. 112, cxxxiv. 1277, cxxxv. 1282–3; Wood (as *Murex*), Ind. Test. pl. xxvii. 95; Fab. Columna

(as *B. variegatum*), Aquat. Obs. p. 53, f. 4; Lamarck (as *T. variegatum*), An. s. Vert. VII. 178; & 2nd ed. Desh. IX. 623; Deshayes (as *T. variegatum*), Encycl. Méthod. III. 1054, plates vol. III. ccccxxi. 2 *a*, *b* (the nomenclature of the plates being by Bory de St. Vincent, Aug. 1, 1824, the text by Deshayes in 1832); Philippi (as *T. tritonis*), Enumeratio, I. 212, & II. 183; Kiener, Iconog. (do.) vol. VIII. 28, ii.; Reeve, Conch. Icon. (do.) vol. II. i. 3 & ii. 3. (L., N., W.) Funchal, Piedade. Not very uncommon.

351. *Trochus* (*Clanculus*) *Bertheloti*, 1839, d'Orbigny (as *Monodonta*), Moll. Canaries, p. 81, vi. 17–20; Philippi, Conch.-Cab. 2nd ed. vol. II. pt. 3, p. 271, xxxix. 17; Fischer in Kiener, Iconog. vol. XI. p. 295, xcv. 1. *Hab.* Madeira. (M., L., N., Jn., W.) From the Gorgulho to Punta de São Lourenço and Porto Santo. Not abundant.—For the original definition of *Clanculus* by de Montfort see Conch. Syst. I. 191. Adams's definition I am unable to understand. The umbilicus in the *T. Bertheloti* is a true, not a "false" one, and though turreted like a corkscrew is perforated to the very apex. The one most prominent feature by which de Montfort differentiates the group is the umbilicus, and to alter his definition to "perforée ou non ombiliquée" is impossible.

352. *Trochus* (*Gibbula*) *Candei*, 1839, d'Orbigny, Moll. Canar. p. 82, vi. 21–23; Philippi, Conch.-Cab. 2nd ed. vol. II. pt. 3, p. 227, xxxiv. 15. *Hab.* Canaries. (L., N., Jn., W.) Everywhere; extremely common both in its typical form and in that of the umbilicated var. of *T. Saulcyi*, of which d'Orbigny made a separate species.

353. *Trochus* (*Trochocochlea*) *colubrinus*, 1849, Gould, Bost. Soc. Nat. Hist. III. 107; Exploring Exped., Shells, p. 183, fig. 223; Watson, 'Challenger' Report, p. 63. *Hab.* Canaries and Madeira. (L., N., Jn., W.) Everywhere; excessively common.—The name *T. Sauciatus*, Koch, as of earlier date, has been suggested for this species, but for Gould's species there is certainty, while for Koch's the habitat is unknown and the description—"céntrum" of the base "vertieft und schwarz-rothgefleckt"—is quite inapplicable. Does any one know what Koch's species was? My lamented friend Dr. Fischer, whose knowledge and judgment were equally trustworthy, regarded (see

Kiener, Iconog. p. 180) it as a variety of the variable and widespread *T. sagittiferus*, Lam. That is where I would place *T. colubrinus*; but abandoning Gould's species, of which we are certain, we drift into the *mare magnum* of mere opinion, and dealing here with the local fauna alone, I feel it best to rest on Gould's nomenclature.

354. *Trochus* (*Ziziphinus*) *conulus*, 1767, Linné, Syst. Nat. p. 1230; Philippi, Conch.-Cab. 2nd ed. II. pt. 3, p. 64, xiii. 8, 9; Fischer in Kiener's Iconog. vol. XI. p. 121, xl. 1, xlix. 1. *Hab.* From the Açores to Mediterranean and Canaries. (M., L., N., Jn., W.) Pretty common.

355. *Trochus* (*Ziziphinus*) *exasperatus*, 1777, Pennant, Brit. Zool. IV. 126: Gwyn Jeffreys, B. C. III. 324; & V. 203, lxiii. 3. *Hab.* From Scotland to Black Sea and Canaries. (M., L., N. Jn., W.) Everywhere; very abundant.

356. *Trochus* (*Ziziphinus*) *granulatus*, 1778, Born, Index Mus. p. 337, xii. 9, 10: Gwyn Jeffreys, B. C. III. 327; & V. 204, lxiii. 5. *Hab.* From the extreme S.W. of Scotland to Mediterranean and Canaries. (M., L., Jn., W.) From Funchal to Labra. Not uncommon.

357. *Trochus* (*Gibbula*) *magus*, 1767, Linné, Syst. Nat. p. 1228: Gwyn Jeffreys, B. C. III. 305; & V. 203, lxii. 1. *Hab.* From S.W. Sweden to Mediterranean and Canaries. (M., L., N., Jn., W.) From Funchal to Punta de São Lourenço. Abundant.

358. *Trochus* (*Ziziphinus*) *striatus*, 1767, Linné, Syst. Nat. p. 1230; Hanley, Ipsa Lin. Conch. p. 321, pl. V. 7: Gwyn Jeffreys, B. C. III. 322; & V. 203, lxiii. 2. *Hab.* From Scotland to Mediterranean and Canaries. (M., L., N., Jn., W.) Everywhere; very abundant.

359. *Trochus* (*Ziziphinus*) *zizyphinus*, 1767, Linné, Syst. Nat. p. 1231: Gwyn Jeffreys, B. C. III. 330, vii. 4; & V. 204, lxiii. 6. *Hab.* From South Norway to Mediterranean and Canaries. (M., L., N., Jn., W.) Everywhere; pretty abundant.

360. *Trophon fusulus*, 1814, Brocchi (as *Murex*), Conch. Foss. Subap. 1st ed. p. 209, & 2nd ed. II. 199, viii. 9; Libassi (as *Murex Spadæ*), 1859, Conch. Foss. Palermo, p. 43, i. 29; Bellardi (as *Pollia*), Moll. terz. Pied. I. 169, xii. 4; Watson (as *Murex*), 'Challenger' Rep. p. 160; Kobelt (as *Trophon*), Jahrb. 1887, p. 120, v. 1. In existence from the Upper Miocene onwards. *Hab.* From the Bay of Biscay and

Açores to Mediterranean. (L., Jn., W.) Labra &c. Not rare.—The dentition of this mollusc excludes it, as Kobelt (*l. c.*) shows, from the genus *Pollia* as well as from *Murex*. With *Trophon* it is further connected by its longish, narrowish, bluntly-pointed, oval operculum, which, when seen in its place within the upturned mouth of the shell, has its apex in front towards the point of the mouth, a little incurved towards the pillar-lip, along which the later edge-layers of growth successively lie. In this connection it should be observed that in Adams's 'Genera' the opercula, when diversely ended, are turned upside down, and the consequent reversal of right and left side is sometimes corrected by the figure presenting the internal, not the external surface. This mistake is avoided in Woodward's most accurate 'Manual,' but it is widespread and sometimes very perplexing, even Philippi has not escaped it. Dr. Brot is nearly always right, as are also Dr. Kobelt and Dr. Fischer, though in the 'Manual' of the latter the different position of shells and opercula adopted in the "gravures" and in the "planches" is somewhat confusing.

361. *Trophon Lowei*, 1897, Watson, *supra*, p. 244.

362. *Truncatella subcylindrica*, 1767, Linné (as *Helix*), Syst. Nat. p. 1248. no. 696 (see Hanley, Ips. Lin. Conch. p. 579); Draparnaud (as *Cyclostoma truncatulum*), Moll. p. 40, i. 28–31; Risso (as *T. truncatula*), Hist. IV. 125, fig. 5; Lowe (as *T. truncatula*), Zool. Journ. V. 280, xiii. 13–18; Philippi (as *Rissoa*), Enumeratio, I. 151. 1, & (as *Truncatella*) vol. II. 133, xxiv. 3; Deshayes (as *Truncatella truncatula*) in Lamarck, An. s. Vert. 2nd ed. VIII. 362 (note); Pfeiffer, Monog. Auric. pp. 186 & 188: Gwyn Jeffreys, B. C. IV. 85, ii. 2; & V. 209, lxxi. 1. *Hab.* From Scotland to Mediterranean and Canaries. (L., Jn., W.) Wherever the shore is shingly, even at the Selvagens.

363. *Truncatella Lowei*, 1852, Shuttleworth, Diag. New Moll. p. 12; Pfeiffer, Monog. Pneumonopomorum, Suppl. 1, p. 7, do. 2, p. 5, do. 3, p 11, no. 14. *Hab.* Tenerife. (W.) Madeira.

Turbo and *Turbonilla*, see *Odostomia*.

364. *Turbo* (*Bolina*) *rugosus*, 1767, Linné, Syst. Nat. p. 1234; Fischer in Kiener, Iconog. vol. XI. p. 41, xv. 1. *Hab.* From Bay of Biscay to Mediterranean, Mogador, and

Canaries. (M., L., N., Jn., W.) Everywhere very abundant. The subgeneric name is given above as Rafinesque (Ann. Nat. p. 144) wrote it in 1815. Risso, following, also wrote it thus in 1826. The form *Bolma* was a mistake of Gray.

365. *Turritella terebra*, 1767, Linné (as *Turbo*), Syst. Nat. p. 1239: Gwyn Jeffreys, B. C. IV. 80, ii. 1; & V. 209, lxx. 6–11. *Hab.* From the Lofotens to the Mediterranean. (W.) Funchal; two specimens.—I give this species with a good deal of hesitation, but I cannot admit either *T. triplicata*, Broc., or *T. bicingulata*, Lam., both of which have been brought to me as Madeiran: the former is very common at the Canaries.

366. *Tylodina citrina*, 1833–4, Joannis in Guérin's Mag. de Zool. I. pl. xxxvi. 1; Vayssière, Moll. Opisth. Marseille, Ann. Musée, 1885, p. 151, v. 130–136. *Hab.* Mediterranean to St. Helena. (Jn., W.) Gorgulho, Funchal, Punta de São Lourenço. A good many young shells. One full-grown specimen I secured in a rock-pool near the Gorgulho fort, west of Funchal, after watching it for a considerable time. As Philippi remarked, its rapid movements are extremely unlike those of *Patella*. The broad membranaceous edge of the shell flaps about in the moving water like a light cloak in a breeze. The bright yellow colour of the animal and of the integument of the shell (which suggested its very graphic name) turns to deep brown in drying or even when preserved in spirit. Rubbed specimens are white with a yellow tint. Adams's (Genera, II. 42, lxi. 4) description and figure are both inadequate and incorrect. Vayssière's description in all its details, as well as his figure of the animal and of the egg-ribbon, are admirable; although the last when I examined it, freshly deposited, seemed flatter than is suggested by his term "demi-cylindrique."

367. *Tylodina Rafinesquii*, 1836, Philippi, Enumeratio, I. 114, vii. 8, & II. 89; Cantraine, Mal. Méd. p. 94. *Hab.* Mediterranean. (W.) One specimen.—The form of the shell in this species is so distinct from that in *T. citrina*, that I find it impossible to accept Vayssière's suggestion and unite the two. I do not gather from his remarks that he has ever seen Philippi's species, whose figure, however, markedly shows the difference.

Tornatina, see *Utriculus*.

Among the shells of Mr. Johnson's collection there occurred a specimen

of *Ungulina oblonga*, Lam. An. s. Vert. v. 487, & 2nd ed. VI. 122, also Sowerby's Genera, pl. xlv. ; "from Porto Santo," but as he had marked the specimen "very doubtful," I have not put it in the List.

Utriculus mammillatus, Phil. (as *Bulla*). — I exclude this species. McAndrew does not give it from Madeira, and in his own copy of his Brit. Assoc. List for the Canaries he corrects and initials the correction from *Cylichna mammillata* to *C. truncata* (which = *U. truncatulus*). Dr. Gwyn Jeffreys has indeed published it (B. C. v. 223) as Madeiran on the strength of shells I sent him, but the identification of these as *U. mammillatus* was not mine.

368. *Utriculus nitidulus*, 1846, Lovén (as *Cylichna*), Index Moll. Scand. p. 16 : Gwyn Jeffreys (as *Cylichna*), B. C. IV. 412; & v. 222, xciii. 2 ; G. O. Sars, Moll. Norv. p. 286, xvii. 19 & xxvi. 3. *Hab.* From north of Norway to Mediterranean. (W.) Three specimens.

369. *Utriculus tornatus*, 1883, Watson, Moll. 'Challenger,' Linn. Journ., Zool. vol. XVII. 335 ; 'Challenger' Mollusca Report, XV. 651, xlviii. 10. *Hab.* Tenerife and Madeira. (W.) Everywhere in great numbers.

370. *Utriculus truncatulus*, 1792, Bruguière (as *Bulla*), Encycl. Méthodique, I. 377. no. 10: Gwyn Jeffreys, B. C. IV. 421 ; & v. 223, xciv. 2 : G. O. Sars, Moll. Norv. p. 285, xvii. 18, xxvi. 2. *Hab.* From North Norway to Mediterranean and Canaries. (Jn., W.) Funchal, Porto da Cruz, Porto Santo. Rather abundant ; the var. *pellucida*, Brown, Ill. p. 4, xix. 45, 46, mixed up with the type form.

371. *Umbrella mediterranea*, 1819, Lamarck, An. s. Vert. VI. 1st part, p. 343, 2nd ed. Desh. VII. 574 ; Delle Chiaje, Mem. IV. 200. no. A. lxix. 5 & 19 ; Delessert, pl. xxiii. 12 : Philippi, Enumeratio, I. 113, vii. 11 ; & II. 88 : Vayssière, Moll. Opisthobr. p. 133–4 &c. pl. vi. 137–150. *Hab.* Mediterranean, Canaries, and St. Helena (?). (L., W.) Gorgulho, Funchal, Punta de São Lourenço, 30 to 40 fms., and Caniçal shore. Rare.

372. *Venerupis irus*, 1767, Linné (as *Donax*), Syst. Nat. p. 1128 : Gwyn Jeffreys, B. C. III. 86, iii. 4 ; & v. li. 5. *Hab.* From South England to Mediterranean, Mogador, and Canaries. (M., L. N., Jn., W.) Everywhere; abundant.

373. *Venus casina*, 1767, Linné, Syst. Nat. p. 1130 : Gwyn Jeffreys, B. C. II. 337 ; & v. 184, xxxviii. 5. *Hab.* From Norway to Mediterranean and Canaries. (M., L., N., Jn., W.) Everywhere ; very abundant.

374. *Venus* (*Cytherea*) *chione*, 1767, Linné, Syst. Nat. p. 1131 :

Gwyn Jeffreys, B. C. II. 332; & v. 184, xxxviii. 3. *Hab.* From South England and Ireland to Mediterranean. (M., L., N., Jn., W.) Everywhere; very abundant.

375. *Venus effossa*, 1836, Bivona in Philippi's Enumeratio, I. 43, iii. 20; Pfeiffer, Conch.-Cab. 2nd ed. XI. 197, xxxii. 1–4; Weinkauff, Conch. Mittelm. I. 115. *Hab.* Mediterranean and St. Helena. (L., Jn., W.) Magdalena, Punta de São Lourenço, Porto Santo. Not rare, but very local.

376. *Venus fasciata*, 1778, da Costa (as *Pectunculus*), Brit. Conch. p. 188, xiii. 3: Gwyn Jeffreys, B. C. II. 334, vi. 5; & v. 184, xxxviii. 4. *Hab.* From the North Cape, Norway, to the Ægean, and existing since the later Tertiary period. (N.) For its right of citizenship in Madeira, see Watson, Journ. of Conch. 1890, pp. 374 & 376.

377. *Venus* (*Cythrea*) *rudis*, 1791, Poli, Test. Sicil. II. 94. 15, 16; Philippi (as *Cytherea venetiana*), Enum. I. 40, iv. 8; & II. 32. *Hab.* From Bay of Biscay and Mediterranean to Black Sea, Canaries, and St. Helena. (L., Jn., W.) Everywhere; very abundant.

378. *Venus verrucosa*, 1767, Linné, Syst. Nat. p. 1130: Gwyn Jeffreys, B. C. II. 339; & v. 186, xxxviii. 6. *Hab.* From Scotland to the Mediterranean, the Cape of Good Hope, and the Indian Ocean. Extant since the later Tertiary period. (M., L., Jn., W.) Gorgulho to Punta de São Lourenço, and Porto Santo. Abundant.

379. *Vermetus gigas*, 1832, Bivona, Effem. Scient. & Lett. p. 5, ii. 1, 2; Philippi, Enumeratio, I. 170, ix. 18 *a* & *b*; Monterosato, Monog. Vermet. Medit. p. 30, iii. 1–3. *Hab.* Mediterranean. (L., Jn., W.) Madeira.

380. *Vermetus rugulosus*, 1878, Monterosato, Enumeraz. & Synon. p. 29; id. Monogr. Vermet. Medit. p. 22, pl. i. 8. *Hab.* Mediterranean. (Jn., W.) Madeira.

381. *Vermetus triqueter*, 1832, Bivona, Effem. Scient. & Lett. p. 6; Philippi, Enumeratio, I. 170, ix. 21; Monterosato, Vermet. Medit. p. 26, ii. 4–9. *Hab.* Mediterranean. (L., Jn., W.) Madeira.

Weinkauffia, see *Scaphander*.

382. *Xylophaga dorsalis*, 1819, Turton (as *Pholas*, but in 1822 amended to *Xylophaga*), Conch. Dic. p. 185: Gwyn Jeffreys, Brit. Conch. III. 120, iv. 3; & v. 193, liii. 4. *Hab.* From North Norway to Mediterranean. (W.) Funchal, Cruz Point, Punta de São Lourenço. Abundant.

The following species, of which I dredged shells in Madeira, have no claim to be included in the above list:—

Off Funchal, even to 50 fms.

Madeiran Land-shells.

Achatina acicula.
Helix pulchella.
Limnæa truncatula.
Planorbis glaber.
Pupa anconostoma.

Foreign Land-shells not found in Madeira.

Assiminea Grayana.
Bythinia tentaculata.
Limnæa peregra.
Neritina fluviatilis.—A species also obtained by Johnson.
Pisidium sp.
Planorbis carinatus.
—— intermedius=submarginatus.
—— sp.
Valvata piscinalis.

Off Santa Cruz, 15 to 20 fms.

Achatina acicula.
Ancylus fluviatilis.
Craspedopoma Lyonnettianum.
Helix cellaria.
—— cristallina.
Helix madeirensis.
—— pulchella.
—— pusilla.
—— vulgata.
Hydrobia similis.
Limnæa truncatula.
Pupa anconostoma.

Off Machico, 15 to 20 fms.

Ancylus fluviatilis.
Helix vulgata.
Hydrobia similis.
Limnæa truncatula.
Pupa anconostoma.

Off Caniçal, 20 fms.

Achatina acicula.
Bulimus ventricosus.
Helix compacta.
—— paupercula.
—— pisana.
Pupa sp.

Off Punta de São Lourenço.

Clausilia exigua.
Helix compacta.
—— paupercula.

Marine species dredged by me or brought to me as Madeiran, but which I reject:—

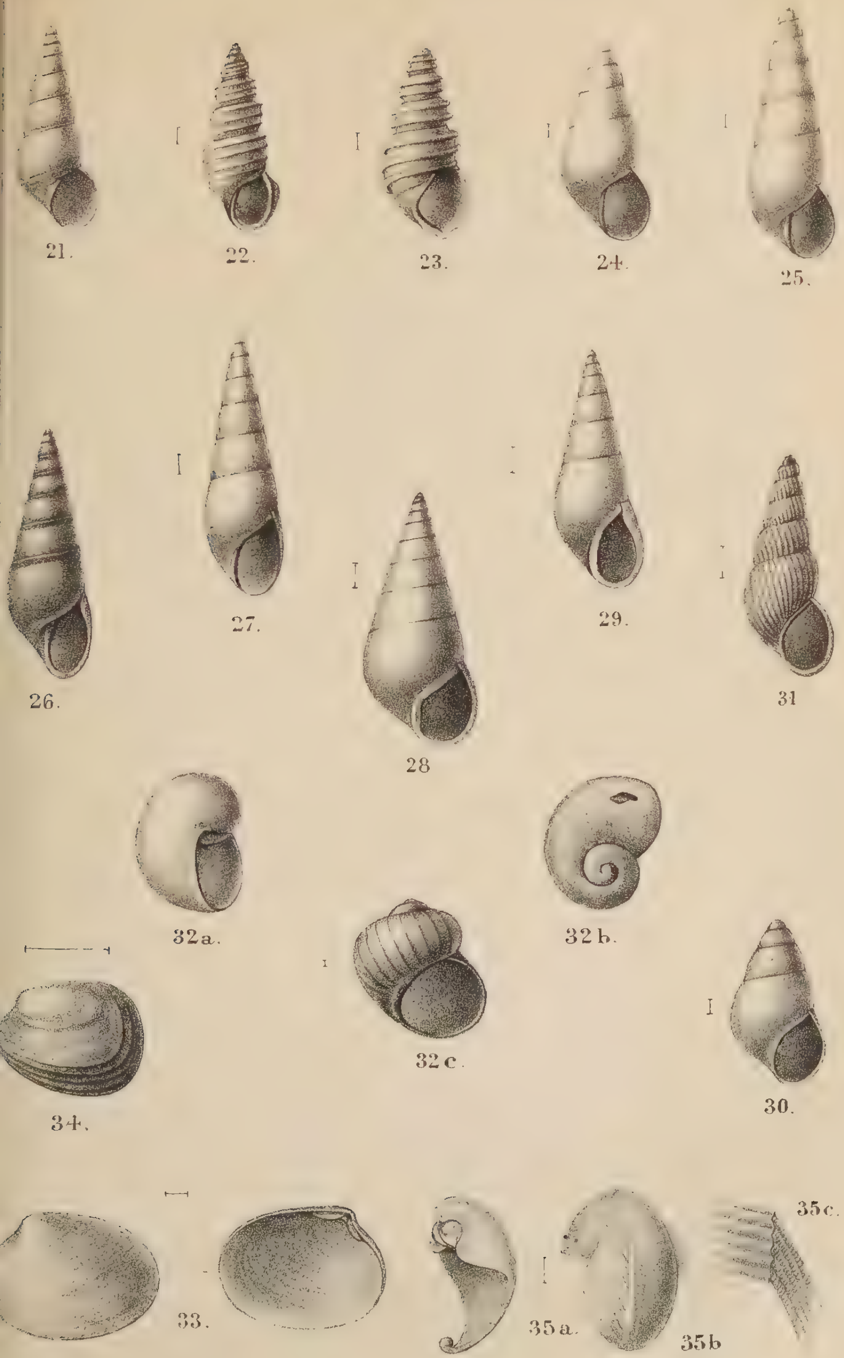
Actæon tornatilis.
Arca incongrua.
—— lactea.
Bouchardia rosea.
Bulla striata.
Cardium edule.
—— magnum.
—— medium.
Cerithium vulgatum.
Conus mediterraneus.
Corbula gibba.
Crania anomala.
Crenella discors.
Crepidula gibbosa.
Cypræa lynx.
Eulima Staloi.—See Jeffreys, P. Z. S. 1884, p. 368.
Hydrobia ulvæ.
Litorina litorea.
—— obtusata.
Lucina Adansonii.
Modiolaria discors.
Murex brandaris.
Nucula nucleus.
Purpura lapillus.
Rissoa Montagui.
Terebra favat.
Trochus Eltonæ.
—— umbilicatus.
Turritella bicingulata.
—— triplicata.
Venus cancellata.
—— exspinata.
—— gallina.
—— striatula.

Such a list as is here presented suggests the caution which should be exercised in working out the Molluscan fauna of this island.

Green del. et lith.

Mintern Bros. imp.

NEW MOLLUSCA FROM MADEIRA.



J. Green del. et lith. Mintern Bros. imp.

NEW MOLLUSCA FROM MADEIRA.

EXPLANATION OF THE PLATES.

[The numbers beneath the figures correspond to those of the order of description in the text and of enumeration in the list on p. 233.]

PLATE 19.

Fig. 1. *Cylichna spreta.*
2. *Amphisphyra flava.*
3. *Philine complanata.*
4. *Philine trachyostraca.*
4 *a*. The same. Small portion of shell, highly magnified, showing sculpture.
5. *Philine desmotis.*
5 *a*. The same. Small portion of shell, highly magnified, showing sculpture.
7, 7 *a*, 7 *b*. *Doridium maderense.*
8. *Pleurobranchus Dautzenbergi.*
9. *Pleurobranchus Lowei.*
10. *Nassa antiquata.*
11. *Murex (Ocinebra) medicago.*
12. *Trophon Lowei.*
13. *Bittium depauperatum.*
14, 14 *a*. *Bittium incile.*
15. *Cæcum atlantidis.*
16. *Natica (Nacca) furva.*
17. *Scalaria rhips.*
18. *Scalaria aspera.*
19. *Scalaria Fischeri.*
20. *Scalaria Smithii.*

PLATE 20.

Fig. 21. *Aclis vitrea.*
22. *Aclis trilineata.*
23. *Aclis tricarinata.*
24. *Eulima fulva.*
25. *Eulima sordida.*
26. *Eulima badia.*
27. *Eulima rhaphium.*
28. *Eulima trunca.*
29. *Eulima inconspicua.*
30. *Odostomia omphaloessa.*
31. *Odostomia (Turbonilla) undata.*
32 *a*, 32 *b*, 32 *c*. *Schismope depressa.*
33. *Montacuta triangularis.*
34. *Coralliophaga Johnsoni.*
35. *Teredo Dallii.*

The Problem of Utility. By Captain F. W. Hutton, F.R.S. (Communicated by Alfred Newton, F.L.S.)

[Read 6th May, 1897.]

Dr. A. R. Wallace has lately published in the Journal of this Society * a paper with the above title, in which he comes to the conclusion that, " whether we can discover their use or no, there is an overwhelming probability in favour of the statement that every truly *specific* character is or has been useful; or, if not useful, is strictly correlated with such a character." I quite admit the force of his argument and the weight of his facts. I acknowledge that many specific characters have been shown to have had a utilitarian origin; but it seems to me that Dr. Wallace's conclusion will not be justified until it has been proved that there is an overwhelming probability that no agency exists capable of producing non-utilitarian characters. This, I venture to think, he has not done; and I should like to be allowed to give my reasons for so thinking.

Dr. Wallace truly says it is very difficult to determine positively that any one of the characters now presented by each organism " *is not, nor ever has been*, useful to its possessor." But also it is often very difficult to determine positively that a character *is, or has been*, useful. These things are generally matters of inference only, and in studying them we should try to make the problem as simple as possible. Now what are the tests by which we recognize a character as of utilitarian origin? Dr. Wallace says that any new species formed under Natural Selection must exhibit either some difference of structure or function adapting it to new conditions, or some distinction of colour, form, or peculiar ornament serving as distinctive recognition-marks; and they may, in addition, have other characters which are correlated with a useful one.

The evidence for this last group of characters is very slight and uncertain, and they cannot be very numerous. At any rate each asserted case would require separate proof, and the principle of correlation should not be used as a cloak for our ignorance. The tests, therefore, are virtually reduced to two: adaptation and recognition-marks.

Recognition-marks can be useful only among those animals

* Journ. Linn. Soc., Zool. vol. xxv. p. 481.

which are capable of recognizing them by the senses. Colour can only be recognized by sight: consequently colours in animals without eyes are not recognition-marks. But in some groups of blind animals colour constitutes a specific character, as in the shells of Lamellibranchs; in these cases, therefore, it must be either adaptive or non-utilitarian. Sculpture might possibly be recognized by touch; but we cannot suppose that in the Mollusca the sexes recognize each other in that way, although ornament, and slight differences in shape of the shell, constitute their chief specific characters. Even with animals possessing eyes there are some specific characters which cannot be regarded as recognition-marks, for they cannot be seen; as, for example, the teeth on the radula of Gastropods. The venation of the wings in Lepidoptera and Trichoptera is obscured by scales or hairs, and yet it often furnishes good generic and sometimes specific characters; occasionally even the venation differs in the two sexes. Some crabs are always covered with seaweeds, and the species cannot be ascertained until these seaweeds have been removed. And, generally, obscure characters cannot be explained as recognition-marks where there are conspicuous characters to answer that purpose. Many species of Orthopterous insects differ from each other in the number or position of the spines on the legs, and no one will suppose that the male of one of these insects stops to count the number of spines on the legs of a female before making love to her. These specific characters, therefore, are not recognition-marks. Are they adaptations?

Adaptations are of two kinds: those which are useful to their possessor, and those which have been useful to former ancestors. We can eliminate the last group by taking only the specific characters of a species the habits of which agree with those of other species of the genus to which it belongs; for in these cases the habits must have remained the same during the whole of its specific life, and the specific characters must, *ex hypothesi*, have been developed by their present possessors. Now can we suppose that the colours which distinguish the shells of the different species of *Tellina*, which live in sand, have any adaptive value? Can we suppose that a spine more or less, or a different arrangement of the tubercles, on the carapace of a crab has any adaptive value? Can it matter in the struggle for life whether a vein in the wing of an insect branches once or twice; or can slight differences in the number or position of the spines on the

legs give one insect an advantage over another? Again, can we suppose the slight differences in the number or shape of the teeth in the species of Helices, or whether they have ten or twenty ribs to the tenth of an inch on their shells, have any adaptive value? Yet they are often good and constant specific characters. Or take the shape of the spicules in the Holothurians or in the Sponges; or the skeleton in the Radiolarians, or the small differences in the leaves of ferns and mosses; or the various ornamentation on the frustules of Diatoms: can all or any of these characters—which are certainly as stable as specific characters which are acknowledged to be useful—can any of them be explained by the principle of utility? If such is the case, which, among two or more species living together, is the best adapted to the conditions, and which the worst? And why has not the worst died out? Take, for example, the different colours and shapes of the shells of Mussels (*Mytilus*), two or more species of which often live together under exactly the same conditions: if one colour or shape is more advantageous than the others, why are the others there? We cannot plead want of time; for many of these species date back to the Pliocene period. Suggestions that it might be this, or it might be that, have no weight with me when I find that the effects which ought to have been produced, if these suggestions were correct, have not been produced: when, for instance, I find that the two species which are compared are equally numerous.

I could give numerous cases in detail if I thought it necessary; but, no doubt, every naturalist who has done systematic work on species could furnish them by the score. So I will restrict myself to one example drawn from a class of facts different from those which I have already mentioned.

There is a genus of small Fruit-Pigeons, called *Ptilopus*, found from the Malay Peninsula through the Malay Archipelago to Australia and Polynesia. It is a large and dominant genus, divided into twelve sections. One of these sections—*Ptilopus* (restricted) —contains twenty-three species, of which no fewer than thirteen *

* *P. pelewensis*, in the Pelew Islands; *P. roseicapillus*, in the Ladrones; *P. ponapensis*, in Ruck Island, Caroline Group; *P. Hernsheimi*, in Kushai, Caroline Group; *P. Richardsi*, in Ugi, Solomon Group; *P. Greyi*, in New Caledonia and the New Hebrides; *P. rarotongensis*, in Rarotonga, Cook's Group; *P. purpuratus*, in Tahiti, Society Islands; *P. chrysogaster*, in Huahine

are found isolated from other species of the section, each on its own island or small group of islands. Now it is highly improbable that all these thirteen species were developed on other islands on which they are no longer found; or that other species of the section *Ptilopus* formerly lived on each of these thirteen islands and have become extinct on them. If it had been a single case only, we might have had some doubt; but when it comes to having to apply the same explanation to more than half of the whole number of species, it seems to me to be absurd. Consequently it appears almost certain that most of these species were developed each on its own island; and, this being allowed, we have the problem of the origin of their specific characters reduced to its simplest form.

If these species originated in the islands in which they are found, the colours which distinguish them cannot be recognition-marks, because there is no other species in each island with which they could be confounded. The colours cannot be due to correlation, because they are the only characters which have changed. They cannot have been useful to ancestors, because they have only lately been developed. And we cannot suppose that they give any special advantage in each island, because all the islands have practically the same climate and the same flora and fauna. This exhausts the resources of the principle of utility, and we are driven to the conclusion that these specific characters have a non-utilitarian origin; and yet they are found "in every individual constituting the species, neither more nor less."

I therefore submit that, whether we can discover the cause or not, there is an overwhelming probability in favour of the statement that these truly specific characters have had a non-utilitarian origin; and if the specific colours have not had a utilitarian origin in these cases, it is quite probable that they may not have had a utilitarian origin in other cases where two or more species of the section are found in the same island; and it follows that recognition-marks do not necessarily arise through selection. Indeed, there appears to be no reason why even adaptations should not arise by the same non-utilitarian process; although,

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and Raiatea, Society Islands; *P. coralensis*, in Carlsoff Island, Paumotu Group; *P. Smithsonianus*, some island, Paumotu Group; *P. Tristrami*, in Hivaoa, Marquesas Group; and *P. Huttoni*, in Rapa, S.E. of the Austral Islands. Further knowledge is more likely to increase than to diminish this list.

when they had attained a selection value, they would be rapidly increased by the principle of utility.

This is exactly the opposite of the conclusion arrived at by Dr. Wallace, except that it applies only to a certain number of characters, while Dr. Wallace would make his conclusions apply to "every truly specific character." If he would change "every" into "many a," I should no longer object to it. The discovery of the principle of Natural Selection by Mr. Darwin and Dr. Wallace marked a great advance in Biology; but it cannot be regarded as final. There is yet much to be learnt; and it seems to me far more probable that there are undiscovered causes at work, than that all the apparently useless characters which I have mentioned are due to the principle of utility. Just as gravitation does not express the whole of the relations between inorganic bodies, so, probably, selection does not express the whole of the relations between organic bodies.

On the Fistulose *Polymorphinæ*, and on the Genus *Ramulina*.

By T. Rupert Jones, F.R.S., F.G.S., and F. Chapman, A.L.S., F.R.M.S.

Part II *.—*The Genus* Ramulina.

[Read 3rd June, 1897.]

Contents.

§ 1. *General Remarks on the Genus* Ramulina.

This genus was instituted in 1875 † on the peculiar characters of some small tubular fossils having enlargements at the junction

* For Part I. see the Linnean Society's Journal, Zoology, vol. xxv. (1896) pp. 496–516.

† Proc. Belfast Naturalists' Field Club, vol. i. 1870–86, Appendix III. 1875, p. 88, pl. iii. figs. 19, 20.

of branches and at intervals along their length. The swollen portions resembled the somewhat loosely-set or distant segments of d'Orbigny's *Dentalina aculeata*; and this latter was regarded as belonging to the new genus. Though there is room for doubt as to the generic standing of d'Orbigny's species above mentioned, yet some aculeate *Dentalinæ* so nearly approach it in form that it may be allowed to remain as such *.

At all events, since 1875 numerous portions of so-called *Ramulinæ* have been figured and described; and others have been discovered, but not yet published; and both as to the characters of separate segments, and of tubes and parts of tubes, simple or branching, they cannot be regarded as parts of any fistulose *Polymorphinæ* yet known †.

Though the latter have more or less ramified outgrowths, these do not radiate from separate subglobular chambers as in *Ramulina*; and the tubules of the latter are very fragile. We may note that d'Orbigny alludes to the fragility of his *Dentalina aculeata*, which we formerly assigned to *Ramulina*.

It is noticeable that *Ramulinæ* "are numerous in the St. Erth clay, although the tubulose *Polymorphinæ* are but sparingly represented" (F. W. Millett, Trans. Roy. Soc. Cornwall, vol. xi.

* Messrs. Balkwill and Millett in their paper on "The Foraminifera of Galway," 1884, p. 15, state that a "Ramuline" specimen from Chalk-marl of Charing, Kent, labelled "*Dentalina aculeata* (d'Orb.)," was obtained from a London dealer "more than twenty years ago"—about 1860? They also observe, "it is perhaps worthy of notice that many of the *Ramulinæ*, in form and texture, resemble the cervicorn outgrowths of certain *Polymorphinæ*."

† In the case of the *Polymorphina proteus* of Beissel, the initial series resembles *Polymorphina* externally, but its internal arrangement is on the plan exhibited by some of the bulbous portions of the ordinary forms of *Ramulina*. The figs. 9 & 10 in pl. xii. represent the two sides of one specimen, which has numerous short tubules set irregularly about the surface. There are faint indications of rugosity. Fig. 11 is the outside, and fig. 12 the inside of a specimen having projections mostly on one side, and these have a cavernous junction with the body. The latter is slightly, and the projections are distinctly, rugose or aculeate. Fig. 13 is a ramuline trifid tube, swollen at the junction of the three parts; aculeate with strong, short, scattered prickles. Fig. 14 shows the section of an irregularly surfaced specimen, with hollow bases in the projections. Fig. 15 is the section of a smooth subspherical specimen with irregular septa. Fig. 16 is subspherical and smooth, with a low rough growth at the apex. The ramuline tube, fig. 13, is grouped by the author as being of the same species as the others; and is of similar formation to the projections in fig. 12, in which the cavernous junction of the outgrowth with the rest of the test is characteristic.—"Foram. Aachener Kreide," 1891.

1895, p. 658). On the contrary, these *Polymorphinæ* are plentiful in the Crag of Suffolk; but *Ramulinæ* are absent there.

Further, more or less perfect and characteristic specimens, having a definite commencement and a great tubular extension, have been met with. These, though markedly distinct from *Polymorphinæ*, have nevertheless their relatively small initial chambers constructed on a Polymorphine plan, just as *Articulina* has a Milioline, *Frondicularia* a Nodosarian or Polymorphine, *Flabellina* a Cristellarian commencement, and so on.

This feature, of course, indicates that *Ramulina* is allied to *Polymorphina* (perhaps subgenerically, as *Articulina* is to *Miliolina*, &c.); and yet another feature, namely the presence of a somewhat Polymorphine and valvular septation in the swollen parts of the branching tubes, also shows that *Ramulina* has somewhat of the nature of *Polymorphina*, but without identifying itself with the latter. This structure, found by us in the nodular or inflated parts of *Ramulina*, shows itself in Beissel's figures of "*Polymorphina proteus*"; and we refer Beissel's form to *Ramulina*, although its exterior is strikingly like that of *Polymorphina gibba* var. *diffusa* *.

In some of Beissel's figures of "*Polymorphina proteus*," notably pl. xii. figs. 9 to 16, we have a Polymorphina-like test giving rise to a *Ramulina*, prickly on the surface, and in every way comparable with those already known from various Cretaceous deposits. At first sight the figures 9–11 and 16 might appear to belong to an ordinary fistulose *Polymorphina*; but examined in the manner shown in figs. 12, 14, & 15, which are half-sections of the test, showing the interior, the subdivision into chambers is seen to differ materially from that of a typical *Polymorphina*, and agrees in many striking particulars with the mode of septation shown in the bulbous or swollen portions of *Ramulina*, as exemplified in thin sections of the bulbs of the latter genus from the Chalk-marl, investigated during the writing of the present memoir.

We note that the late Dr. H. J. Carter has described a subcylindrical "branched form of the apertural prolongation from the summit of *Carpenteria monticularis*," beginning with a fork of two branches, of which the remaining one divides afterwards into three (Ann. & Mag. Nat. Hist. ser. 4, vol. xx. 1877, p. 68,

* See previous part of this Memoir, pp. 505 & 516.

woodcut). He also described and figured the dendriform growth of another specimen (*op. cit.* vol. xix. 1877, p. 212, pl. xiii. fig. 9 *b*). The possible existence of delicate fistulose growths in other *Carpenteriæ* and in *Polytrema* was alluded to by this careful observer in the first-mentioned paper *.

These may possibly come into the category of simple fistulose growths, like those of *Polymorphina* and *Cristellaria* already described; but the branching-tube of the *Carpenteria* differs, by its freedom, length, and special pattern, from those of *Polymorphina*. If this be so, we may extend our foregoing proposition that *Ramulina* has a definite initial structure analogous to, or comparable with, a certain Foraminiferal type, and suggest that, besides *Polymorphina*, some forms of *Carpenteria* and other genera may supply the structural commencement of distinct kinds of such ramifying growths.

Leaving the *Dentalina aculeata* of d'Orbigny as a Nodosarian (so regarded by Brady, Millett, and others), we have to treat of true aculeate *Ramulinæ*. It has already been remarked by one of us †, that it appears desirable to associate the tubular and sometimes globular-chambered *Ramulinæ*, whether smooth or prickly, from Cretaceous strata, with certain recent Foraminifera found in moderately deep water, and figured by H. B. Brady. A careful consideration of the Cretaceous forms of *Ramulina* has since led us to believe that there are four types present in that formation. One of these is a thin-shelled setose form, represented by *R. globulifera*; the second, a coarser form as regards the test-structure, having stronger prickles, we propose to call *R. aculeata* (after J. Wright); the third type, having smooth-surfaced stolon-tubes and bulbs, is referred to as *R. lævis*; the fourth is *R. cervicornis* of the Gault; and a good recent form is the fifth, namely *R. Grimaldii*, Schlumberger.

§2. *Generic Characters of* Ramulina.

Test free or attached; branching; consisting of a calcareous tube, swollen at intervals, so as to form more or less definite, often irregular segments, from which lateral stolons or branches

* Dr. A. Goës, in 1882, suggested that the *Ramulinæ* may be only parts of aulostomatous *Nodosarinæ*, *Polymorphinæ*, *Planorbulinæ*, *Globigerinæ*, and *Carpenteriæ*.—K. Svensk. Vet.-Ak. Handl. vol. xix. no. 4, p. 15.

† Quart. Journ. Geol. Soc. vol. l. 1894, p. 717.

are sometimes given off. The swollen segments are normally subdivided in the interior by septa, which in some cases extend across from wall to wall, but in others are not quite continuous, and so placed as to form a valvular opening. In the attached forms the swollen portion of the test is more definitely Polymorphine both on the exterior and in the interior. The one or more apertures in the forms that are free are circular, being formed by the open end of the calcareous stolon-tube. In the attached forms, the apertures are usually formed by the protracted terminations of the stolon-tubes, and are semicircular in outline where the entire test is adherent to the foreign body. In this point they closely resemble the terminal apertures of the Arenaceous genus *Sagenella*. The surface of the test in *Ramulina* is sometimes smooth, especially in the attached forms; but more frequently the surface is either hirsute, strongly prickly, or tuberculate. An instance is known where *Ramulina* has been found within the chambers of another Foraminifer; also on and in fossil Echinoderm-tests, traversing the ambulacral pores; but this cannot be true parasitism.

With regard to isomorphous forms resembling *Ramulina* in those other groups of the Foraminifera which are characterized by a difference of test-structure, it is instructive to note the comparable forms of *Nubecularia tibia*, Jones & Parker, *N. lucifuga*, Defrance, and *N. nodulosa*, Chapman, in the Porcellanous group. In the *Astrorhizidæ* of the Arenaceous group we note the close resemblance shown in *Aschemonella catenata* (particularly fig. 3 of pl. xxvii. in Brady's Monograph, about which Canon Norman remarks, in a letter, that Dr. Brady has here confused two types under one name). The singular form of *Sagenella* is also strongly suggestive of an attached cervicorn *Ramulina*, although there is no distinct initial series in the figured examples, pl. xxviii. figs. 14, 15.

As the result of a systematic examination of all the published varieties of *Ramulina*, as well as many specimens from the Chalk-detritus (Chalk-marl) of Charing, Kent, the Gault of Folkestone, and other material of our own collecting, we have come to the conclusion that *Ramulina*, as at present known, can be specifically divided into five well-marked types, as described further on. The known specimens are here arranged under their specific heads according to date of publication.

The following *catalogue raisonné* of the published and best

known specimens supplies full evidence of their general agreement with accepted types and subtypes of *Ramulina*, and of the varietal or even specific differences among themselves.

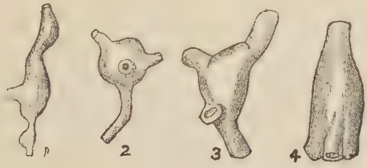
§ 3. *Enumeration of the various Type-species of* Ramulina, *and of the published Figures referable to them.*

1. **Ramulina lævis**, *Rupert Jones*, 1875.

Figs. 1–4.

With the original description of this species given in 1875 there was associated another, nearly similar, form of *Ramulina*, namely *R. brachiata*. Since this latter does not differ from the former in any essential particulars, and, in fact, helps to complete the diagnosis of the species, it is here referred to *R. lævis*.

Specific Characters.—Test free, straight or branching; consisting of pyriform or subglobular segments united by more or less curved stolon-tubes. These latter sometimes proceed laterally from the segments, at others radially. The surface of the test is quite smooth. Texture thick, in this latter respect resembling *R. aculeata*.



References to published Figures and Descriptions of the figured Specimens.

1. 'Polymorphum, Sphærula vitrea lævis,' Soldani, 1791, Testaceograph. &c. vol. i. part 2, p. 115, pl. cxix. fig. G.—Subglobose, smooth; two blunt projections, or short tubes, on one side, make it look like a skin-bag tied up at two places. Mediterranean.
2. *Ramulina lævis*, Jones, 1875, Rep. & Proc. Belfast Nat. F. Club, 1873–74; Appendix III, 1875, p. 88, pl. iii. fig. 19.—Three slightly inflated pyriform segments, united by short stolons, one of which projects laterally at right angles to the line of growth. Surface smooth. Chalk; Ireland.—Fig. 1.
3. *Ramulina brachiata*, Jones, 1875, Rep. & Proc. Belfast Nat.

F. Club, 1873–74; Appendix III., 1875, p. 88, pl. iii. fig. 20. —A nearly spherical segment, with four more or less fragmentary stolon-tubes. Surface smooth. Chalk; Ireland. —Fig. 2.

4. *Ramulina lævis*, Balkwill and Millett, 1884, Journ. Microscopy, vol. iii. p. 84, pl. iv. fig. 7.—A subtriangular, somewhat inflated segment, giving off four straight or slightly curved tubes. Surface of test smooth. Recent; Galway, Ireland.—Fig. 3.

5. *Ramulina Bradyi*, Rzehak, 1895, Ann. k.-k. naturhist. Hofmus. vol. x. p. 223, pl. vi. fig. 5; and *R. exigua*, Rzehak, 1895, *op. cit.* p. 223, pl. vi. fig. 4.—Pyriform and subpyriform segments, with tubular extensions. *R. exigua* exhibits the remnants of three tubes at one end. Surface of test smooth; in *R. Bradyi* slightly grooved. *R. Bradyi* was briefly described by Rzehak in 1891, *op. cit.* vol. vi. part 1, p. 10. Lower Pliocene of Brüderndorf, Lower Austria.—Fig. 4.

2. Ramulina globulifera, *Brady*, 1879.

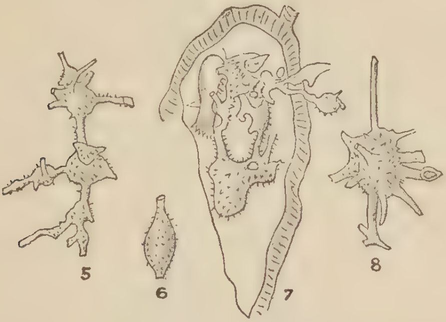
Figs. 5–22.

Specific Characters.—Test free, branching; composed of segments of different sizes, connected by stoloniferous tubes of diverse lengths. Segments from two to eight, or even more, in number; globular or subglobular; but sometimes greatly distorted in appearance (when they usually consist of a single segment with short straight or curved stolon-tubes projecting at various angles). Each segment provided with numerous stolon-tubes (sometimes radiating from different portions of the periphery), and which terminate in other chambers. The stoloniferous tubes, narrow in proportion to the bulk of the segments, are circular in section. Texture hyaline; shell-material usually very delicate and thin; surface hispid or aculeate.

1. *Ramulina globulifera*, Brady, 1879, Quart. Journ. Micr. Sci. n. s. vol. xix. p. 272, pl. viii. figs. 32, 33.—Test free, consisting of from three to seven globular or subglobular chambers, with many tubulated apertures radiating from various parts of the surface. Chambers connected by somewhat long stolon-tubes, usually straight, but sometimes twisted or otherwise distorted. Surface of test covered more or less thickly with fine prickles. The general struc-

ture of the test is very thin and delicate. Recent; Atlantic and Pacific Oceans.—Fig. 5.

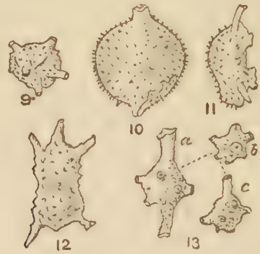
2. *Marginulina*, cf. *Dentalina aculeata*, d'Orb., Berthelin, 1880, Mém. Soc. Géol. France, sér. 3, vol. i. no. 5, p. 35, pl. ii. (xxv.) figs. 10–13 *b*.—Globular, subglobular, and ovoid segments, with remnants of stolon-tubes at opposite ends in figs. 10, 11, and 12. Fig. 13 has one aperture only. The segments are more or less distorted in outline, and therefore cannot be referred to such symmetrical or regular forms as *Dentalina* and *Marginulina*. The surfaces of the tests are thickly clothed with fine prickles. Gault; Montcley (Doubs), France.—Fig. 6.



3. *Moebiusispongia parasitica*, Duncan, 1880, Journ. Roy. Micr. Soc. vol. iii. p. 377, pl. x. (This has been shown by the recent researches of Mr. A. V. Jennings, Journ. Linn. Soc., Zoology, vol. xxv. (1895) pp. 317–319, to be a true *Ramulina*.)—Numerous thin-shelled, inflated, and irregular segments, with stolon-tubes uniting them; surface covered with fine prickles. The test is within a chamber of *Carpenteria raphidodendron*, Moebius, and a few of the stolons pass into the adjoining chamber. Recent; Mauritius.—Fig. 7.

4. *Ramulina globulifera*, Brady, 1884, 'Challenger' Reports, vol. ix. p. 587, pl. lxxvi. figs. 22–28. (Figs. 25 and 27 were given by the same author in the Quart. Journ. Micr. Sci. n. s. vol. xix. 1879, pl. viii. figs. 32, 33.) See also Journ. Roy. Micros. Soc. 1887, p. 915.—For description see No. 1. Fig. 28 shows the peculiar external development of a segment of *Ramulina*, an internal septation being

probably indicated at the constricted junction. Atlantic and Pacific Oceans.—Fig. 8.

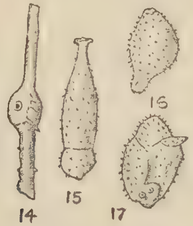


5. *Tinoporus baculatus*, Sherborn & Chapman, 1886, Journ. Roy. Micr. Soc. ser. 2, vol. vi. p. 758, pl. xvi. fig. 24.—A compressed spheroidal segment, bearing about five short tubular processes. Surface of test granulate, or perhaps originally prickly. This specimen was suggested to be referable to *Ramulina* by A. Rzehak in 1891, Ann. k.-k. naturhist. Hofmus. vol. vi. part i. p. 5; and this was further noted by G. A. De Amicis, Boll. Soc. Geol. Ital. vol. xiii. fasc. 2 (1894), p. 108, in his list of known *Ramulinæ* and their localities. London Clay, Piccadilly, London.—Fig. 9.
6. *Lagena lævis*, Terrigi, 1889, Atti R. Accad. Lincei (Memorie), ser. 4, vol. vi. p. 112, pl. vi. figs. 2 & 3.—Subglobular segments, symmetrical; but (viewed from above) laterally compressed. One of the figures shows a single remnant of a stolon-tube; the other has a tube at each of the opposite ends. Surfaces of the tests thickly clothed with fine prickles. Tertiary; Palo, near Rome.—Fig. 10.
7. *Nodosaria*, Wisniowski, 1890, Mikrofauna Iłów Ornatowych Okolicy Krakowa, Part I. p. 15, no. 19, pl. i. (viii.) figs. 22 *a*, *b*. —A subspherical segment with remnants of stolon-tubes at opposite ends. Surface of test covered with fine prickles. *Ornatus*-zone, Middle Jurassic; Cracow, Poland.
8. *Nodosaria hispida*, Haeusler, 1890, Abhandl. Schweiz. Paläont. Gesellsch. vol. xvii. p. 103, pl. xv. fig. 40.—A simple subglobular segment, with stolon-tubes at the opposite ends (broken). Surface of segment bearing numerous well-developed prickles. *Pholadomya*-marls, *Transversarius*-zone, Middle Jurassic; Saint Sulpice, Switzerland.
9. *Lagena protea*, Chaster, 1892, Rep. Southport Soc. Nat. Sci. for 1890–91, p. 62, pl. i. fig. 14.—An irregularly inflated

oblong segment, with two moderately long stolon-tubes, at nearly opposite ends. The surface of the segment clothed with fine hair-like prickles. Recent; Coast of Lancashire. —Fig. 11.

10. *Ramulina globulifera*, Egger, 1893, Abhandl. k. bayer. Ak. Wiss., Cl. II. vol. xviii. pt. ii. p. 310 (118), pl. ix. fig. 62.—An ovoid inflated segment, constricted across the shortest diameter, probably due to the conjunction of two spherical segments. Five tubules disposed peripherally (?) around the segment, three near one end and two at the other. Surface of the inflated segment bearing numerous fine prickles. Recent; Coast of Western Australia.—Fig. 12.

11. *Ramulina globulifera*, De Amicis, 1895, 'Il Naturalista Siciliano,' Anno xiv. p. 48, pl. i. figs. 14 *a*, *b*, *c*.—Three separate segments, all more or less spherical, with stout cylindrical stolon-tubes proceeding from them; also with several smaller tubes disposed over the surface. The test is covered with fine prickles. Pliocene of Bonfornello, Sicily.—Figs. 13 *a*, *b*, *c*.



12. Specimen B—Chapman Collection.—A curved stolon-tube, with two tubules proceeding out of it at right angles, on the curved side. Gault; Folkestone.

13. C—Chapman Collection.—A much compressed segment, with an irregular margin caused by the outgrowth of arrested tubules, one of which is longer than the rest. In one part of the segment there is a perforation, as though the margin was there completed by the coalescence of three tubules. Surface of test bearing a few fine prickles. Gault; Folkestone.

14. E—Chapman Collection.—See Journ. R. Micr. Soc. 1896, pl. xii. fig. 3.—An elongate pyriform segment, terminating at each end in a stolon-tube. The entire surface of the test is clothed with fine prickles. Gault; Folkestone.—Very

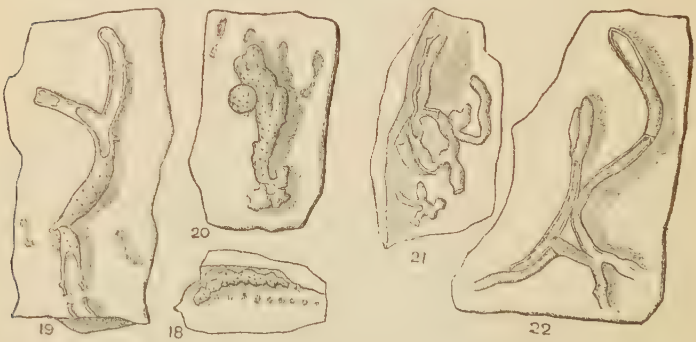
similar to fig. 6, but with a longer and more slender stolon-tube at each end.

15. L—Chapman Collection.—A subglobular segment having a long stolon-tube at each end. The test of the inflated portion is translucent, and exhibits evidence of internal septation. The surface both of segment and stolons bears a few fine prickles, sparsely scattered. Gault; Folkestone.—Fig. 14.

16. P—Chapman Collection.—A double segment, closed at one end and terminating in an open and lipped (?) tube at the other. The commencing (?) segment is subglobular, and has a rather blunt point. The second segment is elongate-pyriform. Gault; Folkestone.—Fig. 15.

17. *Ramulina globulifera*, Brady, Chapman, 1896, Journ. R. Micr. Soc. pp. 582–583, pl. xii. fig. 4.—A pyriform segment of *Ramulina* having remnants of stolon-tubes at the opposite ends. Surface finely prickly. Gault; Folkestone.—Fig. 16.

18. *Ramulina globulifera*. Brady, Chapman, 1896, *loc. cit.* fig. 6.—A much-compressed segment having a stumpy stolon-process and remnants of tubes on an inflated area of the surface. Gault; Folkestone.—Fig. 17.

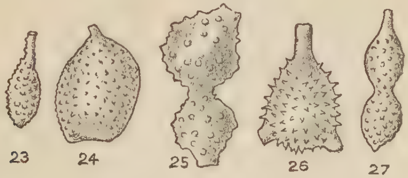


19. *R. globulifera*. Rowe Collection.—Attached to fossil echinoderm tests, passing through the ambulacral pores and forming irregularly wandering tubes on the surface, more or less branching, and occasionally swollen; with prickly surface. Chalk *; Margate.—Figs. 18–22.

* *Ramulina globulifera*, Brady, is catalogued with a doubt in a list of the Cenomanian Foraminifera of Mecklenburg by G. Schacko, Arch. Freund. Nat. Mecklenburg, 1892, p. 157.

3. Ramulina aculeata, *Wright*, 1886.
(*Non* d'Orbigny's *Dentalina aculeata.*)
Figs 23–42.

Specific Characters.—Test free; composed of subangular, inflated segments connected by stout, curved or rarely straight stolon-tubes. The segments almost invariably show a septate division of the interior; the septa, however, nearest the stolon-tubes are always interrupted in the centre, thus forming a valvular or constricted entrance to the tubes. The walls of the test much thicker than in *R. globulifera.* Surface of test bears numerous strong prickles or tubercles; and these appear to be formed of non-tubular shell-material.



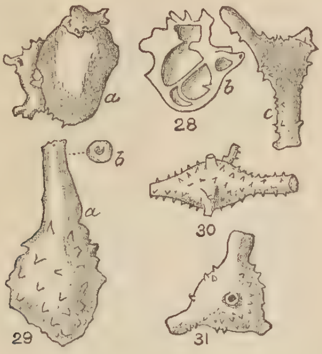
1. "Small flask-like objects, curiously echinulate," Williamson, 1847, Mem. Lit. Phil. Soc. Manchester, vol. viii. p. 78, pl. iv. figs. 73, 74. Named *Dentalina aculeata* in the same work for 1872, ser. 3, vol. v. p. 136.—Test pyriform, and irregularly compressed. Oral apertures prominent, and probably once connected with stolon-tubes. Surface covered with strong prickles. Chalk-marl; Kent.
2. *Lagena distoma-aculeata*, Parker and Jones, 1865, Phil. Trans. vol. clv. pt. 1, p. 348, pl. xviii. fig. 5.—An irregular flask-shaped segment, with an attenuated neck. The surface of the test decorated with blunt prickles or rounded processes. Eocene; Grignon, Paris.—Fig. 23.
3. *Lagena aspera*, Reuss, Brady, 1884, 'Challenger' Rep. vol. ix. p. 457, pl. lvii. fig. 12.—This subglobose specimen differs from *L. aspera*, Reuss, to which species Brady refers it, by being compressed and inequilateral, and by having a narrow oblique tubular aperture at one end and a blunt eccentric projection at the other. The "ento- and ectosolenian" characters are not apparent. The surface is finely tuberculate. Locality? Recent.—Fig. 24.

4. *Ramulina aculeata*, Wright, 1886, Proc. Belf. Nat. F. Club, 1885–1886, Appendix IX., 1886, p. 331, pl. xxvii. fig. 11.—Two asymmetrical subspherical segments, closely conjoined by a short stolon. Surface of test bearing scattered tubercles, the remnants of strong prickles. Chalk; Keady Hill, Ireland.—Fig. 25.
5. *Lagena hispida*, Haeusler, 1887, Neues Jahrb. f. Min. Bd. i. pp. 185 & 189, pl. v. fig. 12.—A subtrigonal and inflated segment *, with remnants of the stolon-tubes at the angles. Gault; Ste. Croix, Switzerland.—Fig. 26.
6. *Ramulina aculeata*, Burrows, Sherborn, and Bailey, 1890, Journ. Roy. Micr. Soc. p. 561, pl. xi. fig. 16.—An elongate, subspherical segment, with remnants of stolon-tubes at the opposite ends. Surface of the test bearing many strong prickles. Red Chalk; Speeton, Yorkshire.
7. *Nodosaria hispida*, Haeusler, 1890, Mém. Soc. Pal. Suisse, vol. xvii. p. 103, pl. xiv. fig. 15.—Two pyriform segments, with a constricted junction, and one extremity produced. Surface tuberculate, probably from the remnants of strong prickles. *Pholadomya*-marl, *Transversarius*-zone, Middle Jurassic; Switzerland.—Fig. 27.
8. *Lagena hispida*, Terrigi, 1891, Mem. Descriz. Carta Geol. Italia, vol. iv. p. 77, pl. ii. fig. 2.—An acute-oval segment, not quite symmetrical; sharp at the ends; one evidently stoloniferous. Surface furnished with numerous distinct prickles. Tertiary; Capo di Bove, Italy.
9. *Polymorphina proteus* †, Beissel, 1891, Abhandl. k. Preuss. geol. Landesanstalt, n. s. part iii., pp. 57–62, pl. xii. fig. 13. —A bulbous, subspherical segment, with three tubes of equal length, apparently on one plane and at nearly equal angles. The surface has a few strong prickles. The section

* A somewhat similar example is figured as *Lagena bicornuta* by Dr. G. Egger, from the South Atlantic (Abhandl. k. Bayer. Akad. vol. xviii. 1893, p. 320, pl. x. figs. 92, 93). It is flattened flask-shape, pinched at the bottom into two short, horn-like, blunt angles; neck protruding; surface roughly pitted and porous.

† The "*Polymorphina proteus*" in pl. ix. figs. 1–56, and pl. xii. figs. 1–8, comprises various common species and varieties; but pl. xii. figs. 9–16 are different and include the portions of *Ramulina* here described. Possibly this should be regarded as a distinct species under the name of *Ramulina proteus* (Beissel). See Journ. Linn. Soc., Zoology, vol. xxv. p. 499, and p. 334 of this paper.

(fig. 28 *b*) shows segmental cavities at the bases of the tubes. From Marl of the zone of *Belemnitella mucronata* in the Upper Chalk; the Frederichsberg, Aix-la-Chapelle.—Figs. 28 *a*, *b*, *c*.

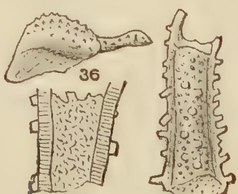


10. *Lagena tuberculata*, Perner, 1892, Ceská Ak. Císaře Františka-Josefa Prague (Palæontographica Bohemiæ, vol. i. pp. 49–65), p. 56, pl. v. figs. 19 *a*, *b*.—A single irregularly flask-shaped segment and stolon-tube. The surface bears a number of strong blunt prickles. The test is thick, as is shown by the orifice, fig. 29 *b*. Chalk; Bohemia.—Figs. 29 *a*, *b*.
11. *Ramulina globulifera*, var. *miocænica*, Rzehak, 1895, Ann. k.-k. naturhist. Hofmus. vol. x. p. 222, pl. vi. fig. 6. *R. Kittlii*, Rzehak, 1895, *op. cit.* p. 221, pl. vi. figs. 7, 9, 11 (also mentioned in a list, *op. cit.* 1891, vol. vi. pt. i. p. 2). *R.* cf. *aculeata*, Rzehak, 1895, *op. cit.* p. 222, pl. vi. figs. 8, 10.—In fig. 6 (our fig. 30) we have a strongly aculeated, elongate-oval segment, bearing four, short, divergent, lateral tubes, and terminated at each end by a stolon-tube (broken). An example of somewhat similar character is shown in fig. 9 (our fig. 31); but here the segment is triangulo-globose, with three large stolon-tubes proceeding from it, and with a fourth, central, smaller tube at right angles to the others. The surface in this specimen is sparsely, though strongly, aculeate. The figs. 7 and 8 are elongate-pyriform segments terminated by stolon-tubes more or less short. The remaining figs. 10 and 11 represent sections of the test, and show marked differences in their thicknesses. The first two

named are from the Bartonian of Brüderndorf, Lower Austria; and the last from the Miocene of Osluwan, Austria. —Fig. 30 ("*miocænica*"); fig. 31 ("*Kittlii*").

32 35 34

12. *Hormosina lateralis*, Grzybowskiego, 1895, Rozpr. Ak. Krakow. Ser. II. vol. ix. p. 186, pl. ii. figs. 2 *a*, *b*.—Irregular and subangulate segments; in one specimen, two connected with a short stout stolon, and marked with irregular projections. Surface decorated with beaded or small blunt processes, in more or less parallel lines along the length of the shell. Tertiary; Carpathians.—Figs. 32 *a*, *b*.
13. *Ramulina aculeata*, Chapman Collection. See Journ. R. Micr. Soc. 1896, p. 583, pl. xii. fig. 7.—A complete segment with fragment of another, and of subglobular form. Surface with strongly developed prickles. Gault; Folkestone.—Fig. 33.
14. *Ramulina aculeata*, Chapman Coll., *loc. cit.* fig 8.—A ong stoloniferous fragment with lateral processes (broken). Surface of test strongly prickled. Gault; Folkestone.—Fig. 34.
15. *Ramulina aculeata*, Chapman Coll., *loc. cit.* fig. 9.—A stoloniferous portion, with stumpy processes, somewhat contorted. Surface covered with strong prickles.—Gault; Folkestone.—Fig. 35.



38 37

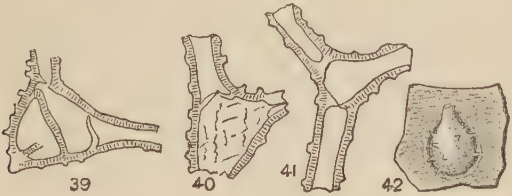
16. H—Chapman Coll. — An attached initial segment of *R. aculeata* adherent to a minute pebble. It is irregularly subpyriform, bending along the edge of the object

to which it is attached, and gives off a stolon-tube of some length, which was probably connected with other inflated segments. The surface of the test is studded with strong, sharp prickles. Gault; Folkestone.—Fig. 36.

17. O—Chapman Coll.—A subglobular segment, having three stolon-tubes radiating from it. The surface of the test is sparsely studded with prickles. Gault; Folkestone.

18. Q—Chapman Coll.—A fragment of one of the stolon-tubes of *Ramulina aculeata*, showing the coarse blunt spines and the perforations of the test. Gault; Folkestone.—Fig. 37.

19. R—Chapman Coll.—A fragment of a stolon-tube of *Ramulina aculeata*. Gault; Folkestone.—Fig. 38.



20. Specimen M; 21. S; 22. T—Chapman Coll.—Three examples of *Ramulina aculeata* (figs. 39, 40, 41) which have been sliced horizontally and medially to demonstrate the presence of septa within the segments. In fig. 39 (M) we have a well-inflated segment, of subtriangular shape; and from two of the corners there proceed stolon-tubes. The interior of the segment is divided by partial and complete septa, somewhat after the manner of *Polymorphina*, although not so regularly arranged. At the junction of the stolon-tube with the segment there exists a partial partition of the shell-cavity, the septum being interrupted either in the middle or at one side near the outer shell-wall.

Fig. 40 (S) is similar in shape to the foregoing, but there are no apparent septa within the cavity of the segment. The junctions of the stolon-tubes with the segment are partially divided by imperfect, valve-like septa; one being thin, and with its free edges pointing up the tube; the other almost completely closing the tube, except a fine median canal, left for intercommunication.

The common triangular arrangement of the stolon-tubes

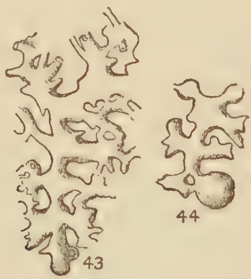
in *Ramulina aculeata* is shown in section in fig. 41 (T), where there is no septation of the internodal cavity; but the tubes are divided from the central portion by a valvular septum in one case; in another by a complete septum (this may, however, be accounted for if the section were not quite median); and at the third tube there is no septum. Gault; Folkestone.

23. *Ramulina aculeata*, Rowe Collection.—A flask-like segment, which has found a *point d'appui* in an ambulacral pore of an echinodermal test. Chalk; Margate.—Fig. 42.

4. Ramulina Grimaldii, *Schlumberger*, 1891.

Figs. 43, 44.

Specific Characters.—Test attached. Having a distinct Polymorphine commencement, and proceeding to a rectilinear outgrowth of great extent, which branches off laterally at almost regular intervals, until it becomes less regular and loses itself in large and small ramifications, sometimes anastomosed. The laterals have racemose endings.

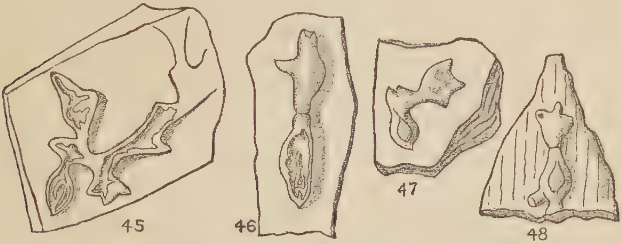


1. *Ramulina Grimaldii*, Schlumberger, 1891, Mém. Soc. Zool. France, vol. iv. p. 509, pl. v.—Test attached to molluscan shells. The outgrowth, specified as above, is sometimes eleven times the length of the commencing Polymorphine series. The outgrowths are not entirely apical, but sometimes start from the sides of the early part of the test. The initial form appears to be that of *Polymorphina gibba*, d'Orb. Recent; between Fayal and Pico in the Azores.—Figs. 43, 44.

5. **Ramulina cervicornis** (Chapman, *Polymorphina Orbignii*, var. *cervicornis*, 1892).

Figs. 45–51.

Specific Characters.—Test attached; commencing with a Polymorphine series, and continuing (usually from the apex, though not always confined to that region) to grow in a strong, branching manner, often closely resembling the antlers of deer. Apertures at the terminal points of the branchlets.

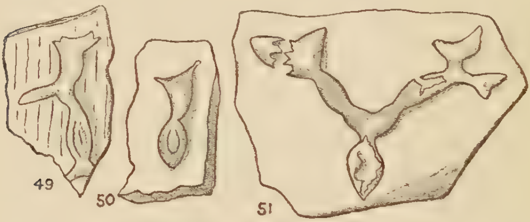


1. *Polymorphina Orbignii*, var. *cervicornis*, Chapman, 1892, Geol. Mag., dec. 3, vol. ix. p. 54, pl. ii. fig. 5.—Test attached to a fragment of *Nucula*. The initial series is that of *Polymorphina fusiformis*, Römer. The cervicorn outgrowth is five or six times the length of the initial series of chambers. It is apical, and, after proceeding for a short distance in a vertical direction, branches off laterally, bearing the longest part of the outgrowth. Gault; Folkestone.—Fig. 45.
2. Specimen A — Chapman Collection. — Commencing series broken open, and revealing a Polymorphine septation; the outline is that of *P. angusta*, Egger. At the apex there is a slight constriction, upon which follows a tubular extension, with a lateral offshoot. The whole is attached to a fragment of molluscan shell.

   It is worthy of notice that the constriction above referred to, as occurring between the Polymorphine series and the outgrowth, probably facilitates the separation of the two kinds of growth, giving rise to *Ramulinæ* without distinct commencements, as in the aculeate examples. Gault; Folkestone.—Fig. 46.
3. D—Chapman Collection.—An elliptical commencement, resembling *P. fusiformis*, Römer, is followed by an apical outgrowth, which, before extending far, sends out a lateral

cervicorn branch. Attached to a piece of molluscan shell. Gault; Folkestone.—Fig. 47.

4. G—Chapman Collection.—This example exhibits an initial Polymorphine structure on the plan of *P. fusiformis*, Römer, but differs from the usual forms of Ramuline commencements in having outgrowths at both ends of the Polymorphine portion. At one end is a short cervicorn outgrowth, at the points of which the apertures are clearly seen; at the other end are the rudiments of two tubes, one springing forth laterally. This specimen is incomplete, and what was possibly the most interesting portion has been removed by the fracture of the *Frondicularia* to which it was attached. Gault; Folkestone.—Fig. 48.



5. J—Chapman Collection.—The initial Polymorphine series, referable to *P. fusiformis*, Römer, is succeeded by an outgrowth at each end. One is definitely cervicorn; and the other (broken) was probably of the same character. Test attached to a fragment of molluscan shell. Gault; Folkestone.—Fig. 49.

6. Chapman Collection. Journ. R. Micr. Soc. 1896, p. 584, pl. xiii. fig. 10.—A Polymorphine commencement and a single process, widening rapidly, subtriangular in form, with an aperture at each of the anterior angles. Gault; Folkestone.—Fig. 50.

7. Chapman Collection. *Loc. cit.* fig. 11.—A dichotomous form, attached. The initial Polymorphine chambers (obscured by fracture) produce two divergent, lumpy, apical tubes; one having a doubly dichotomous, blunt, branching termination; the other ends in a swollen, dichotomous, and, as it were, stunted branch. Gault; Folkestone.—Fig. 51.

§ 4. *Occurrence of* Ramulina.

Ramulina, so far as at present ascertained, makes its first appearance in strata of Jurassic age, having been found in the *Transversarius*-zone of Switzerland and the *Ornatus*-zone of Poland. It occurs in the Neocomian (Bargate) Pebble-beds of Littleton and Chilworth, Surrey *, and in many succeeding formations. Thus we know of it as specimens from various other Cretaceous deposits, such as the Gault of Folkestone, Merstham, and Godstone; and as figures and descriptions of examples from the Gault of France and Switzerland. We have specimens also from the Chalk-marl of Charing and Folkestone, and the Chalk of Kent, the Phosphatic Chalk of Taplow, Buckinghamshire, and the Chalk of Ireland. The Chalk of Aix-la-Chapelle and that of Bohemia have also yielded definite forms which have been figured.

The *Ramulinæ* above referred to are mostly of the types that have the test covered with short prickles: one with the shell thin (*globulifera*); and the other, which we recognize as *R. aculeata*, with a thick test. Since the identity of any of these forms with d'Orbigny's *Dentalina aculeata* is not regarded as satisfactory by some authorities, and as Mr. Joseph Wright has figured a specimen of the latter kind as "*R. aculeata* (d'Orb.)," we use that specific name for these prickly *Ramulinæ*, without reference to d'Orbigny's named specimen, thus, *R. aculeata*, Wright.

Note.—As regards the distribution of *Ramulinæ* in the Gault of Folkestone, it is interesting to note the gradual increase in their numbers from Zone III. (where they first make their appearance in this formation) to the top of the Gault at its junction with the Chloritic Marl; and so, increasingly, upwards to the Upper Chalk.

§ 5. *Distribution and Range in Time of* Ramulina.

1. Ramulina lævis, *Jones*. Chalk; Ireland. Tertiary; Austria. Recent; Ireland.
2. R. globulifera, *Brady*. Jurassic; Poland and Switzerland. Lower Greensand; Surrey. Gault; Folkestone and France. Tertiary; England, Austria, Italy, and Sicily. Recent; Mauritius, West Australia, Lancashire, Atlantic, and Pacific.

* Quart. Journ. Geol. Soc. vol. l. 1895, pp. 717, 718.

3. R. ACULEATA, *Wright*. Jurassic; Switzerland. Gault; Switzerland, Folkestone. Red Chalk; Speeton. Cenomanian; Bohemia. Chalk-marl; Kent. Chalk; Ireland, Aix-la-Chapelle. Tertiary; France, Italy, Austria. Recent; South Atlantic (?).
4. R. GRIMALDII, *Schlumberger*. Recent; Azores.
5. R. CERVICORNIS, *Chapman*. Gault; Folkestone.

Table showing the Range in Time and the Relative Numbers of Forms noticed.

	Jurassic.	Cretaceous.	Tertiary.	Recent.	Entries of		Total noticed.	
					Published forms.	New forms.		
Ramulina lævis, *Jones*	......	2	1	2	5	....	5	59 of both published and new forms here noticed and described.
R. globulifera, *Brady*	2	13	3	5	16	7	23	
R. aculeata, *Wright*	1	17	4	1	15	8	23	
R. Grimaldii, *Schlumberger*	......	......	......	1	1	....	1	
R. cervicornis, *Chapman* ...	......	7	......	......	3	4	7	

The largest number of known *specimens* (*R. globulifera* and *R. aculeata*) occur in the Cretaceous Formations—thus, 26 in the Gault (chiefly at Folkestone), whilst the Lower Greensand, Red Chalk, Lower and Upper Chalk together have yielded 12.

Addendum.—As this memoir was going through the press, we met with the descriptions and figures of two interesting and rare forms of Protozoa, which seem to be closely related to *Ramulina*, in one of the late Dr. H. J. Carter's memoirs (Ann. Mag. Nat. Hist. ser. 5, vol. v. (1880) pp. 446–448). Both of these forms were arranged by him in his Testamœbiformia. One of them, *Holocladina pustulifera* (pl. xviii. figs. 4 *a–g*), irregularly branching, repent, and attached by its root-like ends, has some apparent affinity to *Ramulina globulifera*. The other, *Cysteodictyina compressa* (pl. xviii. figs. 5 *a–e*), coarsely reticulate, repent, and attached throughout, is evidently related to *R. Grimaldii*. Both were found by Dr. Carter in the crevices of Melobesian nodules from the Gulf of Manaar.

REPORT ON THE ACARI collected by Mr. H. Fisher, Naturalist of the Jackson-Harmsworth Polar Expedition, at Cape Flora, Northbrook Island, Franz-Josef Archipelago, in 1896. By A. D. MICHAEL, F.L.S., F.Z.S., F.R.M.S., &c.

[Read 17th June, 1897.]

(PLATE **21.**)

THIS collection was formed by Mr. Fisher under very great difficulties during the Jackson-Harmsworth Expedition. It is necessarily a small one, and consists of five species only: two of these are probably new to science. The most striking features of the collection are the entire absence of anything which can be considered as a specialized local fauna, and the close agreement or relationship between the species collected and those familiar to arachnologists as inhabiting Central and even Southern Europe, and sometimes extending far beyond European boundaries; thus affording an excellent example of the extremely wide distribution of these minute creatures. The same remarks may be made respecting every collection of Acari hitherto made in high northern latitudes, although none have been recorded from so far north as those obtained by Mr. Fisher; but collections of Acari, chiefly very small, have been described from Greenland *, Cornwallis Island †, Spitzbergen and Bear Island ‡, Jan Mayen Island §, Behring Straits &c.||, Iceland ¶, and Siberia and Novaya Zemlya **, &c.

One species in the collection, "*Glyciphagus domesticus*," swarms in houses in England, in flour, dried fruits, &c.; so much so that I at first thought it might have been introduced by the Expedition in their stores; but Mr. Fisher assures me that the place where it was found was far away from their camp, and

* O. Fabricius, 'Fauna Grœnlandica,' &c., Hafniæ et Lipsiæ, 1770. Thorell in Öfvers. K. Vet.-Akad. Förh. 1872, p. 147.

† White, in Sutherland's 'Journal of a Voyage in Baffin's Bay and Barrow's Straits,' London, 1852.

‡ Thorell, in Öfvers. K. Vet.-Akad. Förh. 1871, p. 683. Trouessart in Mém. Soc. nationale Sci. nat. Cherbourg, t. xxix. (1894) p. 185.

§ Capt. v. Wolgemuth, 'Die österreichische Polarstation Jan-Mayen, 1882–83, Beobachtungs-Ergebnisse,' iii. Band, pp. 55, 56.

|| Kramer and Neumann in 'Ur. Dvega Expeditionens Vet.-Iakttagelserd.' iii. 1883.

¶ Trouessart (*loc. cit.*).

** L. Koch in Svenska Ak. Handl. Band 16, No. 5 (1879).

that it could not have been introduced. Another species, *Oribata setosa*, has formed a principal feature in almost every collection of Acari which has been brought from Arctic regions; but it is equally common in England and throughout Central and even Southern Europe. A third species, proposed to be called "*Oribata Fisheri*," is new; but is closely allied to *Oribata antarctica*, which was described by me from specimens found in the Island of South Georgia (Antarctic Ocean)*; but although it is more nearly related to this species than to any other, yet the two vary so little from Central European forms that an acarologist would not be at all surprised at finding both in England.

TROMBIDIIDÆ.

ERYTHRÆUS HARMSWORTHI, n. sp. (Plate 21.)

Length about ·3 mm. Breadth about ·1 mm.

Unfortunately the specimens arrived in such poor condition that I can add little, if anything, to Mr. Fisher's careful drawing which accompanies this paper, and which was made from life on the spot; the species appears to be unrecorded.

Cephalothorax and abdomen very distinctly separated. Whole creature rosy pink, with two irregular longitudinal bands of brown spots on the abdomen. Palpi carmine. Abdomen almost parallel-sided; truncated anteriorly; rounded, but with a slight tendency to be pointed posteriorly. Two longitudinal rows of short straight hairs on the notogaster; five radiating hairs on hind margin. Legs thin, gradually diminishing, with dark transverse bands at the articulations; some fine scattered straight hairs on the legs. The claws are not drawn, and the specimens brought home have lost them. I doubt whether the specimens are mature.

Abundant under stones.

EUPODINÆ.

RHAGIDIA GELOSA, *Thorell.*

Three specimens from the talus. They were coral-red when living. This species has been recorded by Thorell from Spitzbergen and by L. Koch from various parts of Siberia and Novaya Zemlya. The genus *Rhagidia* appears to me to be identical with *Norneria*, Canestrini: and in my opinion the two should not be retained. *Norneria* is a genus containing very

* Michael, in Beih. z. Jahrb. Hamburg. Anst. v. p. 12 (1895).

West, Newman chromo

few species, the type being Italian. The colour was not recorded in the descriptions published by Thorell or Koch, as those authors had spirit-specimens only.

ORIBATIDÆ.

ORIBATA SETOSA (*K. L. Koch*).

Several specimens.

ORIBATA FISHERI, n. sp.

Length about ·48 mm. Breadth about ·28 mm.

This species is more closely allied to *O. antarctica* from South Georgia (Beih. z. Jahrb. Hamburg. Anst. v. p. 12, 1895) than to any other, but is distinguished from it by the smaller size, the lamellar hairs, interlamellar hairs, and rostral hairs not being serrated, the form of the pseudo-stigmatic organs, and the wider translamella.

Pale olive-brown, slightly translucent. Lamellæ about half the length of cephalothorax; they are blades almost on edge and narrow posteriorly, becoming gradually wider and more horizontal as they approach their anterior ends. Cusps of the lamellæ very long, wide, almost horizontal, slightly truncated anteriorly; lamellar hairs springing from the middle of the truncated edge. Translamella a narrow but very distinct blade on edge. Pseudo-stigmatic organs very short, sessile, slightly curved, *gradually thickened from the proximal to the distal end*, which is truncated but slightly rounded. Lamellar hairs, interlamellar hairs, and rostral hairs long, thick, almost rod-like, *not serrated*. First tectopedia without any free anterior projecting points. Abdomen smooth; progaster undulated, *i. e.* very convex in the centre, concave at the sides. Pteromorphæ short, *i. e.* running only about one-third of the length of the abdomen. A sparse line of extremely fine hairs round the notogaster. Legs rather short, fourth pair scarcely passing the posterior end of the abdomen; the coxæ and femora of the third and fourth legs have distinct blades. Claws tridactyle, but the lateral claws so thin as not to be seen without a highish power.

Several specimens from the talus.

TYROGLYPHIDÆ.

GLYCIPHAGUS DOMESTICUS (*de Geer*).

Two or three specimens from the talus.

Observations on Termites; with Descriptions of new Species.

By G. D. Haviland, M.A., M.B., F.L.S.

[Read 3rd June, 1897.]

(Plates 22–25.)

Introduction.

The Termites here described are chiefly those collected by myself in South Africa, the Malay Peninsula, and Borneo. I am, however, indebted to Mr. C. Hose, of the Sarawak Government Service, and to my brother in Natal for many of the specimens. The importance of the collection depends on the completeness of the material, and on the fact that I spent much time and trouble in examining the nests. The collection was made from about 1000 nests belonging to about 90 different species. The actual number of specimens in the collection must be about 100,000. Mr. Ridley of Singapore gave me the first stimulus to collect Termites and helped me in many ways; but to Dr. David Sharp, who is responsible for my having undertaken the description of the species, I am especially indebted for having not only revised the proofs, but, in my absence, superintended the preparation of the plates. I am also indebted to Herr Wasmann for type-specimens of his species.

All the measurements are given in millimetres. The length of the soldier's head is measured from the vertex to midway between the anterior articulations of the mandibles. The length of a mandible is measured from the anterior articulation to the apex. The measurements and characters which are given of a wing are those of an anterior wing detached at the natural suture.

Classification.

In the matter of genera I have followed Hagen. His genera admit of distinctions common to every caste. The genus *Termes* contains numerous species of very diverse forms and habits, yet it cannot be subdivided by characters common to every caste. The genus *Calotermes* is as widely distributed as the genus *Termes*, but has only a tenth as many species, and they are rather uniform in habits and readily separable from those of the genus *Termes*. The genus *Termopsis* bears much the same relation to the genus *Calotermes* that the genus *Hodotermes* does to the genus *Termes*: both appear to have a more limited distribution and a more ancestral form. The two species

Hodotermes (*Porotermes*) *quadricollis*, Rambur, of Chili, and *Hodotermes* (*Stolotermes*) *brunneicornis*, Hagen, of Tasmania appear to belong to distinct genera, but I have seen no specimens. Nor have I seen the *Anaplotermes pacificus* of F. Müller.

The genus *Termes* is so large that Hagen, who tried to make several genera of it, failed owing to the incompleteness of his material. I also have failed, and think that in the interests of naturalists the attempt should be postponed. I have avoided the use of named subgenera because they have no place in the Linnean system of nomenclature, and therefore cause confusion. The genus does, however, present natural groups, and these I have attempted to define, but more material and further examination will alter the definitions and limits I have given. The groups can seldom be distinguished by characters common to every caste, nor are the limits of the groups the same if we rely on the soldiers as if we rely on the males.

The largest forms of the genus are fungus-growers. There is an American group of large termites, represented by *T. dirus*, which are almost certainly fungus-growers; the soldiers have a pair of lateral horizontal spines on the pronotum. There are three Old World groups of fungus-growers. The most important is represented by *T. bellicosus*; it builds tall mounds, the imago and soldiers are of large size, and the latter have a transparent tip to the labrum and a toothless margin to the mandibles. The second is represented by *T. vulgaris*; it builds insignificantly small mounds or none at all; the imago is large, but the soldiers are of moderate size, have a few bristles at the tip of the labrum and a minute tooth at the middle of the cutting-margin of each mandible, or at any rate of the left one. The last group, represented by *T. incertus*, has individuals of moderate size and quite different habit from those of the previous groups.

A remarkable group in which the soldiers have a very large foramen in front of the head, from which when angry they can discharge a copious viscid milky fluid, has been given the subgeneric name *Coptotermes* by Herr Wasmann. The group is quite worthy of generic rank.

Another remarkable group, in which the soldiers have a minute foramen in front of the head, and a long labrum reaching to the tips of the strongly toothed mandibles, was given the subgeneric name *Rhinotermes* by Dr. Hagen. This group also is worthy of generic rank. I here describe the soldiers of two species

which are evidently different from and yet allied to this group, though I have not yet obtained an imago.

These groups, the fungus-growers, *Coptotermes* and *Rhinotermes*, have soldiers with pronotum more or less flat, and antennæ of usually more than 14 segments, and abdominal papillæ usually easily visible. They have imagos in which the wings show the median nerve midway between the submedian and subcostal. The remaining groups, containing much the larger number of the species, have imagos in which the wings show the median nerve much nearer the submedian than the subcostal, and soldiers whose antennæ have seldom more than 14 segments. It is to these that Dr. Hagen gave the subgeneric name *Eutermes*; they comprise numerous groups, with difficulty recognized by the imagos, but readily recognized by the soldiers. The name *Eutermes* had been previously applied by Heer to some fossil forms of the genus *Termes*, known only from the imago, and in one case only from the wings. The name was limited by Dr. Fritz Müller to a much smaller group, that in which the soldiers have rudimentary mandibles and a long conical rostrum. He raised this group to generic rank: it is a natural group, worthy of generic rank, if indeed it be not worthy of forming several genera, but it was not in this sense that Heer or Hagen used the name *Eutermes*. There are a few species in which the wing shows the median nerve nearer to the submedian than the subcostal, and in which the soldier has a flat pronotum. *T. planus* has a small flat pronotum with an anterior median process, a character found in every caste. *T. tenuis* has a large, flat, anteriorly bilobed pronotum in the soldier. But in most of the groups in which the median nerve is markedly nearer the submedian than the subcostal, the pronotum of the soldier is saddle-shaped with much depressed lateral angles and elevated anterior lobe, and the antennæ have from 12 to 14 segments. These groups contain the greater number of the species, and fall into three sets. In the first the mandibles of the soldiers have a cutting-margin and the labrum is chitinized; in the second the mandibles, though of considerable length, have no cutting-edge, and the labrum is small and white, with two minute acute diverging lobes; in the third the mandibles are rudimentary, and there is a long perforated conical rostrum in front of the head.

The species of the genus *Termes* seem in some cases to be very

distinct and readily distinguishable, and in other cases to pass indistinguishably into one another. In those groups in which the species are easily distinguishable, I trust that my descriptions will be found sufficient. In the groups in which the species are not easily distinguishable, I have not attempted to outdo nature in distinctness; indeed, in this respect I am conscious of short-comings. In every case I trust that more reliance will be placed on my specimens than on my descriptions.

Characters.

The following brief remarks on the external characters of Termites refer almost entirely to the species of the genus *Termes*, for on the other genera I have nothing new to advance.

The enormous number of individuals in a nest, all of whom may be considered as the children of the same parents, provides material for the study of normal variation and of specific limits scarcely to be met with elsewhere. The great difference of character in the different castes also introduces new conditions in the classification of species, and in the study of heredity not often to be met with.

In the genus *Termes* the soldier is by far the best caste to determine species from; not only is the soldier easier to determine than the male, but it is found in almost every nest, and usually wherever the workers go. Though the imago was the caste on which Hagen founded most of his species, though it is the form found fossil in amber, though it is the form caught flying round a lamp at night, yet it is generally absent from the nests, and is often insufficient for the determination of species. I have not found the characters of the wings very useful or reliable. In one case I have based species on differences in the imago, though I could see no difference whatever in the soldier; but as a rule my species are based chiefly on apparent differences in the soldiers.

There are two external characters which are correlated in the soldiers and the males of the genus *Termes*: the abdominal papillæ show a corresponding degree of development, and the number of segments of the antennæ is approximately in the proportion of 8 to 9. The characters of the antennæ are probably more important than any others in the determination of the species. It is easy enough with a little care to determine whether the apical segments are present or, as often happens,

are broken off, for the apical segment is of a different shape from the others. Although the segments of the antennæ are fewer in the soldier than in the male, they are generally longer and more cylindrical, so that the antennæ of the soldiers are often as long as or longer than those of the imago. The antennæ of the workers, on the other hand, are always much shorter, yet the number of segments which compose them is never less than in the soldier and never more than in the male. The actual length of the antennæ in the genus *Termes* seems to be but little correlated with the actual number of segments which compose them, whether we compare the different species, or whether we compare the different castes. Long antennæ go with long legs, and this is true whether we compare caste or species. Long legs and long antennæ go with much walking and foraging; and this is true when we look to differences between species, but not when we look to differences between castes. Soldiers with long slender legs belong to species which forage for food at a distance from the nest: soldiers with short stout legs belong to species sluggish in their movements, and which venture but little from home.

Blindness amongst the soldiers and workers is more universal than it is in ants. There seems no reason to doubt that the blindness is connected with the mode of life. The impossibility of attributing the blindness to the inherited effects of disuse, seeing that none of the parents in any of the species are blind, utterly discredits such an explanation in the case of other blind animals.

In all the castes the abdomen varies greatly in size and appearance according to the nature of its contents.

The winged imagos have an unconquerable desire to leave the nest, and to run the risk of dangers from which not one in many thousands escapes. By this means it is that interbreeding and distribution are effected. Dr. Fritz Müller aptly compared the winged individuals to perfect flowers, and the neoteinic individuals to cleistogamic flowers. The comparison may be carried a step further. In temperate climates the winged forms appear in early summer; in equatorial regions they appear for the most part in simultaneous swarms at favourable seasons, whilst in some species they seem to be constantly produced in small numbers the whole year round. The problems of when to swarm and how many imagos to produce seem to be solved in

nearly the same ways as the problems of when to flower and how many flowers to produce.

They fly but feebly, allowing themselves to be carried by the wind, and could scarcely cross more than a mile or two of water.

The wings are soon shed across a transverse basal line. The method of breaking off the wings is to elevate them; this will be found effective in dead insects. The live insect uses its legs and abdomen to elevate its wings, or in other cases pushes them against some object; yet in some cases the live insect will shed all four wings with inexplicable rapidity. Their wings not only prevent their burying themselves and hiding, but on a perfectly level surface are a danger to them, for birds are seen to pick up those with wings in preference to those without.

At the time of swarming the males and females of the genus *Termes* pair, the male following the female and often clinging to her abdomen; but there are no copulatory organs, and the sexual organs are not at that stage mature. In *Termopsis* and *Calotermes* (pp. 372–373) it seems that the males and females do not run about in pairs.

In most, if not in all species a pair of termites can found a nest without assistance. Smeathman, however, states that in *T. bellicosus* such pairs are protected by any soldiers and workers who may find them, and are by them treated as kings and queens. Some observations made by my brother strongly confirm this statement in respect of the fungus-growing species. Those who have not lived in hot climates seem to have difficulty in realizing the extent to which the ground may be permeated by termites.

The females do not differ from the males in head and thorax, though careful measurements may find the male to be the smaller. The abdomen of the females becomes at the last moult different from that of the males on account of a characteristic change in the ventral plates of the 7th, 8th, and 9th abdominal segments. In all species of the genus *Termes* the abdomen subsequently swells to many times its original size; but this swelling is not accompanied by any moulting; the chitinous plates do not alter, but become separated by the distension of the intervening cuticle. Dorsally and ventrally secondary chitinization occurs in some groups in the cuticle anteriorly to the original chitin plates. In most groups there are present a number of minute lateral thickenings, usually coloured, and bearing each a hair.

When, as in most species, the queen is enclosed in a royal cell

from which she is too large to escape, a familiarity with the nest and habits of the species will lead to her discovery without much trouble; but in all species other than the fungus-growers the king can leave the royal cell, and generally does so when he finds the nest is being opened. In many species, however, the queen wanders about the nest, and she then seeks, like the king, to avoid observation when the nest is being opened. In such cases there is only one way of searching methodically for her. Remove the nest with as little disturbance as possible to a convenient place free from the attacks of ants, a large table with its feet standing in water is the best place. Break the nest into fragments, remove each fragment one by one, examine it carefully, and put it aside in a safe place so that the search may, if necessary, be gone through a second time. If the nest has been broken into fragments before it has been much disturbed, the king will be found in the same fragment as the queen. If the nest be broken into fragments gradually, the king, if found at all, will generally be found in the fragment last examined. The longest time I spent searching through one nest was three days. I found a king; the queen escaped me, but I feel confident that was due to my own want of care, and she was really there.

I have found colonies which I believed to be through some accident queenless; and there are no doubt species in which a single colony owns several nests; but the rule is that every nest has a true royal pair. I have found as many as six true royal pairs; they were, as is always the case, in the same royal cell, their tarsi were injured, presumably as the result of quarrelling.

When there is a true queen, she is, so far as my observations go, always accompanied by a true king. When there is more than one true queen, the number of true kings is generally equal to them; but often it is less, and occasionally it is greater. The king has no copulatory organs; from Prof. Grassi's observations it is probable that in *Calotermes* copulation nevertheless does take place. In *Termes malayanus* I have reason to think that the king fertilizes the eggs after they are laid; indeed, copulation in the case of kings and fully-grown queens of most species of the genus *Termes* is apparently impossible.

I raised neoteinic forms artificially in two species of *Calotermes*. In species of the fungus-growers neoteinic forms have never been found. In five cases I removed the royal pairs from nests

of *T. malayanus*, and after three or four months again examined the nests. In three out of the five cases substitution pairs exactly resembling the original ones, with well-formed wing-stumps, were present; in the other two cases I could not find a royal cell, and believe that the loss had not been repaired.

Natural neoteinic forms are very abundantly found in some species, especially in those whose soldiers have a saddle-shaped pronotum and are mandibulated. In forms with nasute soldiers I found neoteinic queens in only two species, *T. borneensis* and *T. matangensis*. Neoteinic queens are generally raised in considerable numbers, and become fewer in number as they grow older. They are always found in the same part of the nest, although, unless few in number, they cannot all occupy the same cell.

By neoteinic individuals I mean fertile individuals the condition of whose thorax makes it clear that they have never been capable of flight. Though the true queens are always accompanied by kings, the neoteinic queens are often consortless. They may be accompanied by one or more true kings, or by one or more neoteinic kings; but the kings are almost invariably less numerous than the queens, and are in many cases wholly absent. This last conclusion indeed rests on negative evidence only, and in the case in which I am most positive (*T. matangensis*, nos. 358 & 359) neither eggs nor young larvæ were present in the nests, though winged males and females were abundant.

The function of the soldiers I believe to be defence, and defence only. Some able observers have arrived at a different conclusion; but on what grounds I am not clear. There is a vast difference in functions of offence and functions of defence: the most successful defence is to prevent attack; defence has half failed when attacks must be repulsed. The great enemies of termites are ants; and the function of the soldiers seems to me to be to defend any openings in the nests by putting their heads in the way whilst the workers build fortifications. Those soldiers which have a saddle-shaped pronotum and well-developed mandibles are very sluggish, and seem quite useless when a nest is opened. It is the nests to which these belong that birds are most fond of; but while broken nests may be used to bait bird-traps, unbroken nests seem sufficiently strong to resist the birds.

Those soldiers which have a saddle-shaped pronotum and rudimentary mandibles secrete a clear viscid fluid from a sac which

occupies a great part of the head, and opens by a duct which passes down the rostrum. The soldiers may be seen to dab a little of the fluid on the antennæ of their enemies by a quick movement which is clearly a modification of the shaking movement so often seen in worker termites. By this means such enemies as ants are placed *hors de combat* when they do not, as they generally do, avoid these soldiers. But such a mode of defence would seem quite useless in dealing with birds and mammals. However, all the species of the section to which *T. umbrinus* belongs traverse the jungle, returning home by daylight exposed in long lines which take an hour or more to pass one spot, the soldiers walking beside the laden workers. In most of the species the soldiers and workers retreat when disturbed; but in *T. longipes* the behaviour is unusually active. The workers vanish at once beneath sticks and leaves; and if specimens be not quickly secured, they will soon be very hard to find. The soldiers, on the other hand, rush to the attack, not in line, but singly; climbing every leaf and stalk, they stand with uplifted rostrum challenging the enemy. But these species with rostrum and rudimentary mandibles are not the only ones which secrete a viscid fluid from the head. The soldiers of *T. foraminifer*, which have a saddle-shaped pronotum and long crooked mandibles, also have a minute orifice in the front of the head. In all the species of *Rhinotermes* the soldiers have a similar foramen and a shallow groove which runs from it to the tip of the labrum. *T. malayanus* has a similar minute foramen, the orifice of a sac occupying the middle of the head. Most soldiers of the fungus-growers and also those of *T. sulphureus*, when angry, discharge a viscid fluid from large salivary vesicles opening into the mouth. The most remarkable form of orifice in the front of the head is in the section *Coptotermes*. The soldiers of both *T. Gestroi* and *T. travians* have very large orifices in the front of the head from which, when angry, they emit a copious white viscid fluid which runs down to the mandibles. The soldiers of *T. Gestroi* are very ferocious. The species is one which deliberately attacks and destroys live trees. The workers build up a thick earthy crust round the stem of the tree for the height of 7 or 8 feet from the ground; beneath this crust they leisurely seek out weak spots and penetrate to the centre of the tree. If the crust be broken, the workers very quickly retreat; but the soldiers rush to the attack, a milky white fluid standing between their open

jaws, they lift themselves up and then hammer their heads against the tree, producing a rattling sound. If left alone they soon retire under cover; but if one breaks into their retreats, out they come again in great excitement, hammering their heads, opening and shutting their jaws, and discharging their milky secretion. In the section of the fungus-growers to which *T. bellicosus* belongs the workers run away to their subterranean passages when the nest is being opened, whilst the soldiers stay to defend the nest; generally the smaller soldiers are more active than the larger, for they run about whilst the larger occupy the crevices of the nest and the cavities of the fungus-buds, there they wait and bite at anything which comes in reach. The soldiers of this group can generally produce the rattling sound. In this accomplishment, *T. carbonarius* has reached the highest stage of development, for the soldiers can hammer in rhythmic unison. At first a few begin irregularly, then they get into time, and the others take it up. Every soldier in the exposed portion of the nest stands up and hammers with his head; the blow is given thrice in very quick succession, and then there is an interval of two seconds. The noise they produce reminded me of wavelets lapping on a shore. This trick of hammering with the head is seen in only a few species; it is clearly a modification of the shaking movements so often seen in workers.

I have not found a species without soldiers, though Dr. Fritz Müller found some in America. I have rarely found a nest without soldiers, though in *T. lobatus* I have done so. Generally the soldiers are numerous, perhaps about a fifth part as numerous as the workers. It is only just before the last moult that they take on their peculiar form. In many species there are two kinds of soldiers, the larger and the smaller, without intermediate forms. This is especially noticeable in the group of fungus-growers to which *T. bellicosus* belongs, and in *Rhinotermes*, in which the difference is very marked. In two species of soldiers with rostrum and rudimentary mandibles (*T. trinervius* and *T. longipes*) a similar condition occurs.

To the workers I have not paid much attention. The amount of colouring and chitinization is correlated with the period during which they are exposed to light. A broad head, slender legs, and arched abdomen goes with activity and the habit of foraging for food. A narrow head, short stout legs, and fusiform abdomen go with a sluggish habit. The workers not only collect the

food and build the nest, but also nurse the young, and may be seen carrying the eggs and young larvæ to places of greater safety. In some species they certainly take care of the queens. I have spirit-specimens of *T. hospitalis* and *T. malayanus* in which many of them are biting the abdomen of the queen. I have no doubt this is to stimulate her to move and escape from danger. The curious irregular contractions seen in the queen's abdomen when alive I attribute also to endeavours to escape; for I have reason to believe that they do not occur when the queen is at rest, and not in normal egg-laying. In some species the workers will bite an intruder, but more often they are only too anxious to escape.

The structure and position of termites' nests are very various. They agree in having the outer part closed so as to exclude their great enemies the ants, the entrances are generally few and well protected. There are, however, some exceptions to this rule, of which the most remarkable is the nest of *T. latericius*, which has two or three vertical shafts, an inch or two in diameter and about three feet deep, opening on the surface of the ground. *T. hospitalis* also has one or more large openings at the summit of the nest. Several species of the group to which *T. lacessitus* belongs, and which build round nests on the branches of shrubs, may also have several exposed openings into the nests.

The different groups of the genus *Termes* build nests of different characters; the most remarkable that I have seen are those of the fungus-growers, so well described by Smeathman in the case of *T. bellicosus*. The nests of the American fungus-growers seem unfortunately never to have been described. It was noticed by Smeathman that in some cases the nests of nearly allied species were more easily distinguished than the insects which built them. This is especially true of the species allied to *T. nemorosus*, which builds turret-nests closely like the turret-nests described by Smeathman. On the other hand, the appearance and shape of the nests are much modified by conditions; thus the mound-builders can live without a mound in cultivated ground, where mounds are not permitted. In the case of *T. malayanus* I have found such nests partially deserted from having become water-logged.

All the species whose soldiers have a distinctly saddle-shaped pronotum seem to use proctodeal discharges in the building of their nests. The fungus-growers, on the other hand, do not do

so, but moisten the pellets of clay which they bring with fluid from their mouths. In species of *Coptotermes* and *Rhinotermes*, and in *Termes tenuior*, I did not see what manner of cement was used. *T. planus* lived in shallow chambers eaten in the wood, much after the manner of *Calotermes*, and had no buildings.

Observers in America and Europe have concluded that the same colony often possesses several nests, only one of which is inhabited by fertile individuals, whose eggs and young are carried to the other nests. I do not doubt that this is so with a few species; I believe it to be so with *T. Gestroi*; nevertheless it is not so with the great majority of species which I have collected. Further, the evidence for such conclusion is, for the most part, negative, and therefore to be treated with great caution. As the search for king and queen goes on hour after hour without success, exhausted patience induces strong wish for a conclusion; and it is then that the difficulty arises of keeping the influence of wish from upsetting the even balance of judgment.

Family TERMITIDÆ.

The Termitidæ, commonly known as White Ants, are insects feeding on wood and dead vegetable matter, living socially in colonies of sterile and fertile individuals, which grow very slowly and have no pupa-stage. Antennæ situated in a shallow fossa at the side of the head just above the base of the mandibles. Mandibles powerful, except in the soldiers of some species. Maxillæ with double chitinous hooks and long 5-segmented palpi. Head hinged to the prothorax by means of a pair of lateral cervical sclerites. Tarsi of 4 segments, the distal as long as the three proximal together. Pronotum, mesonotum, and metanotum distinct. Abdomen of 10 segments; the ventral plate of the basal segment absent; that of the apical segment divided, and bearing at the lateral ends a pair of short cerci; that of the 9th segment in the larva, and often in the adult, with a pair of small papillæ near the centre of its posterior border.

Males with a pair of compound eyes placed just above the antennal fossæ, and for the most part a pair of ocelli situated near their inner borders. Frequently there is a median fenestra. When young there are two pairs of large, membranous, nearly equal wings, which in rest are superposed and project far beyond the apex of the abdomen; these wings are used in flying from

the nest and then shed across a transverse basal line, leaving subtriangular wing-stumps. The vas deferens opens behind the ventral plate of the 9th abdominal segment. The males live permanently along with the females, but there are no copulatory organs.

Females when young closely resemble the males. The ventral plates of the 8th and 9th abdominal segments are divided, and the halves are small and separated. When the female becomes the mother of a colony, her abdomen enlarges by dilatation of the cuticle between the chitinous plates; and sometimes there is secondary chitinization extending forwards from the anterior borders of the plates.

The soldiers are sterile, wingless, and for the most part blind. Their head is chitinous and strong, peculiarly and variously modified for defence. The segments of the antennæ are more elongate than in the males and females, and fewer, generally in the proportion of 8 to 9. The mandibles are very various in the different species, but very characteristic of each species, and quite different from those in the males and workers. The gula is large and firmly united to the head, generally for the greater portion of its length. The cervical sclerites are larger than in the males and workers. The thorax and abdomen are generally but little chitinized; the latter is generally more quadrate than in the workers. Some individuals have rudiments of ovaries, and some of testes: but the ventral plates of the 8th and 9th abdominal segments are always entire.

The workers are wingless and for the most part blind; they are but little chitinized, and larval in appearance. The head is round, the antennæ are shorter than in either male or soldier, and the number of segments intermediate. The mandibles are short and powerful, and covered by the obtuse labrum. In species which nest in the wood on which they live the form is cylindrical, and the legs shorter than the abdomen. In species which wander much in search of food the thorax is considerably narrowed, and the legs longer than the abdomen.

Termites inhabit all the warm regions of the earth in countless numbers. They are unable to withstand a prolonged winter's frost. Their greatest enemies are ants. Their chief means of defence is their power of burrowing and building.

Synopsis of the Genera.

Antennæ of more than 20 segments.	
Pronotum with convex anterior margin and strong lateral processes	1. *Hodotermes.*
Pronotum with anterior margin straight or concave	2. *Termopsis.*
Antennæ of not more than 20 segments.	
Pronotum large and arched, with concave anterior margin	3. *Calotermes.*
Pronotum various	4. *Termes.*

In this synopsis *Hodotermes quadricollis*, Rambur, of Chili, and *Hodotermes brunneicornis*, Hagen, of Tasmania, are not considered. They probably belong to distinct genera, but I have seen no specimen.

Gen. Hodotermes, *Hagen.*

Eyes small, but present in every case; ocelli absent. Fenestra absent. Antennæ of from 25–32 segments, the 1st, 2nd, 3rd, and 4th decreasing successively in length Suture well defined. Pronotum with convex anterior portion and strong lateral prominences. Legs slender, the proximal segment of the tarsus as long as the 2nd and 3rd together. Cerci short, 2-segmented. Abdominal papillæ slender (according to Hagen, present even in the female).

Male with broad round head. Epistoma not prominent. Tarsi without plantulæ. Anterior wing-stumps not overlapping the posterior. Wings more than 4 times as long as broad; the costal area traversed by several branches from the subcostal nerve.

Soldier with head large, ferruginous, subquadrate. Mandibles large and strongly toothed, covered at the base only by the short broad labrum. Thorax and abdomen yellow. Pronotum large. Mesonotum and metanotum broader than the abdomen, flat, and projecting horizontally much beyond the under portions of the thorax.

Worker with head broad and orbicular. The thorax much narrower than the abdomen.

The species of *Hodotermes* work by daytime in the open. They enter holes in the ground, but their nests are still unknown.

There are a few species in Africa and in the North-west of India.

HODOTERMES HAVILANDI, *Sharp.* (Pl. 23. figs. 1, 2.)

Soldier 13 mm. long; head ferruginous, mandibles with black tips, antennæ, thorax, and abdomen ochroleucous. Head subquadrate, breadth from 3·5 mm. to 4·2 mm., length slightly less. A pale spot in the position of the ocellus. Antennæ of 27 to 28 segments. Labrum 1·5 mm. broad by ·7 mm. long. Mandibles 2·7 mm. long; apical tooth strong, subulate; middle tooth subtriangular, basal tooth short and broad. Gula 2 mm. long, its distal half broad and free. Pronotum with strong antero-lateral processes, converging lateral margins, and a more or less concave posterior margin. Mesonotum with uniformly rounded lateral margins, and slightly convex posterior margin. Metanotum with rounded lateral margins; the posterior margin has a broad central lobe, but is concave towards either side.

Worker 10 mm. long, more or less purple castaneous. Head to 3·5 mm. broad. Antennæ of 30 to 32 segments. Pronotum narrower than the mesonotum. Femora reaching to the apex of the abdomen.

Hab. Natal (*Colenso, Weenen*).

Gen. TERMOPSIS, *Heer.*

Eyes small. Ocelli absent. Fenestra absent. Antennæ of 23 to 27 (?) segments. Y-suture obscure. Pronotum nearly flat, with concave anterior margin. Legs stout, the proximal segment of the tarsus scarcely longer than the next. Posterior femora not nearly reaching the end of the abdomen. Cerci long, 4- to 6-segmented. Abdominal papillæ slender, but absent in the female.

Male with head ovate. Antennæ of 27 (?) segments. Epistoma not prominent. Tarsi with plantulæ. Anterior wing-stumps with convex margin, much larger than the posterior, and overlapping them at the base. Wings less than 4 times as long as broad, the costal area traversed by several strong branches of the subcostal nerve. The areas of the wing occupied by reticulated nervures.

Soldier with large quadrate head, bright testaceous in colour, posteriorly ochraceous. Some of the soldiers have eyes, more often they have none. Antennæ of 23 to 25 segments. There

is a strong projecting ridge at the anterior margin of the antennal fossa. Mandibles black, half as long as the head or longer, the margin with short subtriangular teeth. Labrum small, subquadrate. Gula long and united to the head for almost all its length.

The workers appear to be imperfectly differentiated from the larvæ.

The genus is found in California and Central America. Hagen described the males and females of *Termopsis angusticollis* from California, and the soldiers of *T. occidentis* from the west coast of Central America. In the Cambridge Museum are soldiers from California in spirit; presumably they belong to *T. angusticollis*; they differ from those of *T. occidentis* in having a longer head and a much straighter anterior margin to the pronotum. The relative size of the 2nd and 3rd segments of the antennæ seems inconstant.

Gen. Calotermes, *Hagen*.

Antennæ of not more than 20 segments. Fenestra absent. Y-suture obscure. Pronotum large and arched, the anterior margin concave, nearly parallel to the posterior, the lateral margins rounded. Femora short, the hind legs seldom reaching to the apex of the abdomen. Cerci 2-segmented. Abdominal papillæ short, absent only in the female.

Male with head ovate and convex in profile, with compound eyes and ocelli. Antennæ with the segments larger towards the apex. Epistoma not prominent. Feet usually furnished with plantulæ. Anterior wing-stumps with convex border much larger than the posterior which they overlap. Either the costal area of the wing is veined, or the median runs in close contiguity with the subcostal nerve. The submedian and its branches very faint.

The abdomen of the female is never much swollen.

Soldier with strong head often subtruncate in front. Eyes represented by a pale spot, rarely pigmented. Antennæ short. Mandibles black, strong, cutting, generally toothed.

Worker larval in appearance, cylindrical in shape. Head pale. It is probable that all to whom accidents do not happen eventually become winged fertile individuals.

Nestless, living in the hollows which they make in eating wood; they pass solid oval grass, and do not build covered ways,

though they may stop up cracks with moist proctodæal discharges. Their societies do not number more than a few hundred individuals. The species are as widely distributed as are those of the genus *Termes*, but they are only a tenth part as numerous.

Calotermes domesticus, n. sp. (Pl. 23. figs. 3–6.)

Male 5 mm. long, stout, ochraceous above, paler below. Ocelli in contact with the eyes. Antennæ of 16 segments, the 2nd slightly larger than the 3rd. Pronotum 15 mm. long, ·8 mm. broad. Front wing-stumps quite covering the hind ones. Wings 6 mm. long by 1·8 mm. broad, silvery when dry, transparent when wet; 4 or 5 strong nervures cross the costal area: the median joins the subcostal beyond the middle. The hind legs reach the 5th abdominal segment.

Female with the abdomen not elongating more than in the male, but becoming much deeper.

Soldier 4 mm. long. Head 1·3 mm. broad, nearly black, posteriorly atropurpureous, truncated in front, and forming an angle of less than a right angle with the mandibles. Antennæ pale, of 12 segments, the 2nd and 3rd very short. Below the antennal fossa is a strong anteriorly projecting spine. Mandibles subtriangular, with cutting-margin and incurved tips. Gula very short and almost free. Lateral cervical sclerites very large, more than half as long as the head. Pronotum more than a semicircle, as broad as the head, and longer than the mesonotum and metanotum together. Hind legs reaching to the 5th segment of the abdomen.

Worker 6 mm. long. The abdomen broader than the head or thorax.

Hab. Singapore and Sarawak. Plentiful in every house. Type, No. 376.

Calotermes pinangæ, n. sp.

Female 5 mm. long, slender, castaneous. Ocelli in contact with the eyes. Pronotum slightly narrower than the head. Tarsi pale. Hind legs reaching to the 4th abdominal segment.

Soldier 5 mm. long. Head ·9 mm. long, broad, cylindrical, the anterior portion black, truncated, making with the mandibles an angle greater than a right angle, the posterior portion testaceous. Antennæ pale testaceous, of 10 or 11 segments, the 3rd very short. Labrum nearly covering the closed mandibles. Mandibles

castaneous, strong, with incurved tips, the margin of the right with two short broad teeth, that of the left with two or three smaller teeth. Gula more than half as long as the head, but united to it only near the base. Lateral cervical sclerites about a quarter as long as the head. Pronotum slightly broader than the head, quadrilateral, with very concave anterior margin. The 9th, 10th, and often the 8th dorsal plate of the abdomen are latericious in colour.

Worker 6 mm. long, slender.

Hab. Sarawak. Type, No. 235.

CALOTERMES DENTATUS, n. sp.

Female 4·5 mm. long. Ocellus in contact with the eye. Antennæ of 11 segments. Pronotum reniform. Wing 4·3 mm. long, 1·1 mm. broad; costal area narrow, not nerved, the median contiguous to the subcostal throughout its length. Legs not reaching to the end of the abdomen. Ventral plate of the 7th abdominal segment nearly as broad as long.

Soldier 5 mm. long. Head 1·4 mm. long, ·9 mm. broad, bright testaceous, anteriorly obliquely truncate, the truncated surface slightly concave. Antennæ of 10 segments, the 2nd longer than the 3rd. Labrum reaching to two-thirds the length of the mandibles. Mandibles ·6 mm. long; tips black, incurved, the middle of the cutting-margin of each mandible with a single tooth directed transversely. Gula narrow, broad in the apical third. Pronotum as broad as the head; anterior margin deeply concave, the lateral margins converging posteriorly. Hind legs reaching to the 7th abdominal segment.

Worker 6 mm. long, slender, cylindrical.

Hab. Sarawak. Type, No. 355.

CALOTERMES BREVICAUDATUS, n. sp.

Male 4·5 mm. long, badious above, paler below. Head 1 mm. broad. Ocellus in contact with the eye. Antennæ of 13 segments, the 2nd scarcely longer than the 3rd. Pronotum slightly narrower than the head, with pale T-shaped mark. Wing 6 mm. long, 1·7 mm. broad, the costal area narrow and not nerved; the median contiguous to the subcostal through its whole length. Hind legs exceeding the short abdomen.

Female with the ventral plate of the 7th segment semilunar.

Soldier varying in size, from 7 mm. to 5 mm. long. Head

testaceous, darker anteriorly, subcylindric, obliquely truncated; the larger 2·3 mm. long, 1·3 mm. broad; the smaller 1·4 mm. long, ·9 mm. broad. Antennæ of 11 or 12 segments, the 2nd scarcely longer than the 3rd. Labrum obtuse, reaching two-thirds of the length of the mandibles. Mandibles ·8 mm. long in the larger soldiers, broad and testaceous at the base, black at the tip, with a single tooth on the right and two teeth on the left. Gula narrow, broader in the distal third, united to the head for nearly its whole length. Pronotum with postero-lateral corners rounded, and posterior margin broadly and obscurely lobed. Hind legs reaching to the 7th segment of the abdomen.

Worker 8 mm. long, cylindrical.

Hab. Sarawak. Type, No. 237.

CALOTERMES BORNEENSIS, n. sp.

Male 7 mm. long, badious above, pale below. Ocellus slightly separated from the eye. Antennæ of 12 segments, the 2nd subequal to the 3rd. Pronotum slightly broader than the head, reniform. Wing 17 mm. long, 1·8 mm. broad, umbrinous; usually but not invariably the costal area is narrow and not veined, and the median is strong and runs in close contiguity to the subcostal. Hind legs reaching to the 6th segment of the abdomen.

Female with the ventral plate of the 7th segment parabolic.

Soldier 8·5 mm. long. Head dark testaceous, paler behind, 2·4 mm. long, 1·7 mm. broad, anteriorly with two broad rounded tubercles separated by a median depression. Antenna of 11 segments, the third longer than either 2nd or 4th. Labrum obtuse, reaching nearly to the tip of the mandibles. Mandibles 9 mm. long, nearly black, margin slightly toothed. Gula narrow in the basal half, broader towards the apex, united to the head for almost all its length. Pronotum testaceous, as broad as the head. The hind legs reach to the 8th segment of the abdomen.

Worker 10 mm. long, cylindrical.

Hab. Sarawak. Type, No. 439.

CALOTERMES ARTOCARPI, n. sp.

Male 10·5 mm. long, bright testaceous, paler below, wing-stumps castaneous. Ocellus large, almost in contact with the eye. Antennæ of more than 13 segments, the 2nd and 3rd subequal. Pronotum broader than the head, the lateral margins convex. Anterior wing-stumps large, covering the posterior.

The ventral plate of the 7th abdominal segment broader than that of the 6th or 8th, that of the 9th small and narrow.

Soldier from 11 to 12 mm. long. Head 3·7 mm. long, 2·6 mm. broad, aurantiacous, with a broad, shallow, concave area above the epistoma. Antennæ of 16 segments, the 2nd and 3rd subequal, the 4th much shorter. Labrum short, rounded. Mandibles 3 mm. long, black except at the base, the right with two large teeth, the left with many small ones. Gula narrow in the lower two thirds, broad in the upper third, united to the head for almost its whole length. Pronotum as broad as the head. Hind legs exceeding the abdomen.

Worker 9 mm. long.

Sarawak. Type, No. 177.

CALOTERMES DURBANENSIS, n. sp.

Soldier 8 mm. long. Head orange, testaceous. Antennæ of 13 segments, the 3rd much larger than the 2nd. Labrum short and broad. Mandibles black, upcurved, the right with one large tooth below the middle, the left with several smaller teeth. Gula somewhat narrow in the lower part, broad towards the apex, united to the head for nearly its whole length. Pronotum broad, with rounded lateral margin. Hind legs reaching nearly to the apex of the abdomen.

Worker 8 mm. long. Pronotum, mesonotum, and metanotum broad and arched.

Natal (Durban).

Gen. TERMES, *Linn.*

Antennæ of not more than 20 segments. Pronotum various, seldom large or arched. Cerci of 2 to 3 segments.

Fertile individuals with compound eyes and (except in *T. tenuis*) lateral ocelli. Feet without plantulæ. Anterior wing-stumps with nearly straight margins, seldom much larger than the posterior. Costal area of the wings narrow and not veined; the subcostal seldom gives off any branch, and the median only a few.

Soldier with head variously modified for defence in the different species, blind, either with cutting-mandibles, or with means of discharging a viscid fluid from a conical projection in the front of the head. The soldiers may be of different sizes.

Workers very variable, often narrowed at the thorax.

The species of *Termes* differ much in their habits, but they

almost all build nests of some kind. They inhabit all the warm regions of the earth, and number probably from two to three thousand.

A Synopsis of the Sections, based on Characters of the Soldiers.

A. Pronotum rather large and flat, projecting laterally beyond the underparts.	
a. Fungus-growers.	GROUP.
Antennæ of 17 segments, 3rd longer than 2nd. Labrum with transparent tip	*bellicosus.*
Antennæ of 16 or 17 segments, 3rd shorter than 2nd. Labrum with a few bristles ..	*vulgaris.*
Antennæ of 14 or 15 segments, 2nd as long as 3rd and 4th together	*incertus.*
b. A large foramen in the front of the head. Labrum short	*Gestroi.*
c. A minute foramen in the front of the head. Labrum as long as the toothed mandibles.	
Antennæ of 16 or 17 segments	*nasutus.*
Antennæ of 13 segments	*æqualis.*
d. Pronotum half as broad as head, with an anterior median spine	*planus.*
e. Pronotum broad, its anterior margin bilobed	*tenuis.*
B. Pronotum small, saddle-shaped, with raised anterior lobe and depressed lateral angles.	
f Mandible with piercing-tip and cutting-margin. Labrum short, but chitinized.	
Labrum entire. Mandibles with basal portion straight	*dubius.*
Labrum entire. Mandibles curved even from the base	*sulphureus.*
Labrum entire. Mandibles strong, incurved, with or without a strong tooth	*dentatus.*
Labrum lobed. Mandibles curved even from the base	*bilobatus.*
g. Mandibles long, but without piercing-tip or cutting-margin Labrum small, white, with minute, acute, diverging lobes.	
Left mandible much bent. Abdomen white.	*nemorosus.*
Mandibles setiform. Abdomen white	*setiger.*
Mandibles setiform. Abdomen coloured....	*comis.*
Left mandible much bent. Abdomen coloured.	*foraminifer.*
h. Mandibles rudimentary. Head with perforated conical projection.	
Antennæ of 14 short segments	*atripennis.*

Antennæ of 12 or 13 segments. Head ochraceous. Rostrum slender	*regularis.*
Antennæ of 12 or 13 segments. Head fulvous. Rostrum conical	*singaporiensis.*
Antennæ of 14 segments, 3rd shorter than the 4th	*lacessitus.*
Antennæ of 14 segments, 3rd as long as or longer than the 4th	*hospitalis.*

Section with Termes bellicosus *for Type.*

Male large. Antennæ of 19 segments, 3rd longer than the 2nd. Epistoma prominent and rounded. Ocelli large. Fenestra obscure. Pronotum with straight anterior margin and arcuate posterior margin. Anterior wing-stumps scarcely larger than the posterior. Median nerve midway between the subcostal and submedian, and branched 3 or 4 times. Hind legs exceeding the abdomen. Abdomen broad. Abdominal papillæ present.

Female with the abdomen enlarging to such an enormous size that she cannot drag it with her feet. The lateral cuticle of the abdomen smooth and white.

Soldier with broad glabrous head. Antennæ of 17 segments, the 3rd longer than the 2nd. A pale spot in the position of the compound eyes. Fenestra minute, perforate or imperforate. Labrum reaching to the middle of the mandibles, with white translucent tip. Mandibles black, powerful, upcurved, with pointed tips and toothless cutting-margin. Gula nearly uniform in breadth. Pronotum, mesonotum, and metanotum broad and flat, projecting well beyond the under portions of the thorax. Legs long and slender. Abdominal papillæ present. There are two distinct sizes of soldiers; the head of the larger is proportionally broader than that of the smaller.

Worker with head variable in size, chitinized and coloured. A pale spot in the position of the compound eyes. Fenestra large. Antennæ of 18 segments. Mesonotum narrow. Hind legs slender, considerably exceeding the abdomen.

Fungus-growers. Nest terrestrial, forming a conical mound with a hard outer shell. Royal cell massive, supported by delicate laminæ of clay. When the soldiers bite, they often emit a transparent fluid from their mouths.

T. dives, *T. fatalis*, *T. gilvus*, and *T. Azarellii* belong to this section.

TERMES CARBONARIUS, *Hagen.*

Male 18 mm. long, black, the mandibles, antennæ, labrum, and legs testaceous. Ocelli separated from the eyes by a full diameter. Fenestra minute. Antennæ of 19 segments, the 3rd more than twice as long as the 2nd. Pronotum without pale mark, semilunar, the anterior margin slightly concave. Wing 24 mm., umbrinous; the subcostal gives off 2 or 3 nervures towards its apex and has some ill-defined reticulation along its posterior border; the median branched once or twice before the middle and once or twice beyond it, it is equidistant between the submedian and the subcostal; the submedian gives off 4 or 5 broad unbranched nerves and 4 or 5 finer branched ones. Abdominal papillæ short, widely separate, the pale basal areas small.

Female with the ventral plate of the 7th abdominal segment narrower and not half as long again as the preceding. Abdomen of the queen reaches a length of 50 mm., and the membrane is smooth.

Soldiers: the larger 16·5 mm. long. Head 4·5 mm. broad and the same in length, black, testaceous beyond the level of the antennæ. A very distinct transparent spot in the position of the compound eye. Fenestra minute. Antennæ of 17 segments, the 3rd twice as long as the 2nd. Labrum ovate quadrate, with acuminate white tip, reaching to the middle of the mandibles. Mandibles 3·2 mm., upcurved, with piercing-tip and toothless cutting-margin. Gula 1 mm. broad, nearly uniform. Thorax and abdomen castaneous above, ochroleucous below. Pronotum with anterior and posterior margins bilobed, the postero-lateral margins convex. Mesonotum as broad as or broader than the pronotum, anterior margin curving into a postero-lateral corner, the posterior margin lobed. The metanotum is shorter than the mesonotum and has a straight instead of a lobed posterior margin. The femora reach nearly to the apex of the abdomen. The abdominal papillæ are well developed. The smaller soldier 11·5 mm. long. Head 3·4 mm. long, 3 mm. broad. Mandibles 2·4 mm. long.

Workers 8 mm. long, castaneous above. Head various in size up to 2·8 mm. broad. A transparent spot in the position of the compound eye. Fenestra large. Antennæ of 18 segments. Epistoma prominent. Thorax narrow. Abdomen with a high dorsal arch.

Singapore; Malacca; Siam; (Borneo?).

TERMES MALACCENSIS, n. sp.

Soldiers: the larger 12 mm. long; head ferruginous, thorax and abdomen ochroleucous. Head 4 mm. long, 3·7 mm. broad, triangular-ovate. A small pale spot in the position of the compound eyes. Fenestra minute. Antennæ of 17 segments, the 3rd more than twice as long as the 2nd, which is short. Labrum obovate-oblong, with acuminate white tips reaching beyond the middle of the mandibles. Mandibles 2·7 mm. long, with incurved piercing-tip and toothless cutting-margin. Gula ·7 mm. broad in the middle, broader in the upper third. Pronotum with bilobed anterior margin, the lateral margins nearly straight, rapidly converging, the posterior margin nearly straight. Mesonotum narrower than the pronotum, the anterior and posterior margins curving to meet at an angle. The metanotum nearly as broad as the pronotum, the anterior margin curving sharply, the posterior margin slowly, to meet at a postero-lateral angle. Posterior femora exceeding the abdomen. The dorsal surface of the abdomen with numerous long hairs. Abdominal papillæ well developed. The smaller soldier 8 mm. long. Head 2·6 mm. long, 2·4 mm. broad. Mandibles 2 mm. long.

Worker 8 mm. long. Head 2·5 mm. broad, latericious. Antennæ of 18 segments. Dorsum of abdomen much arched.

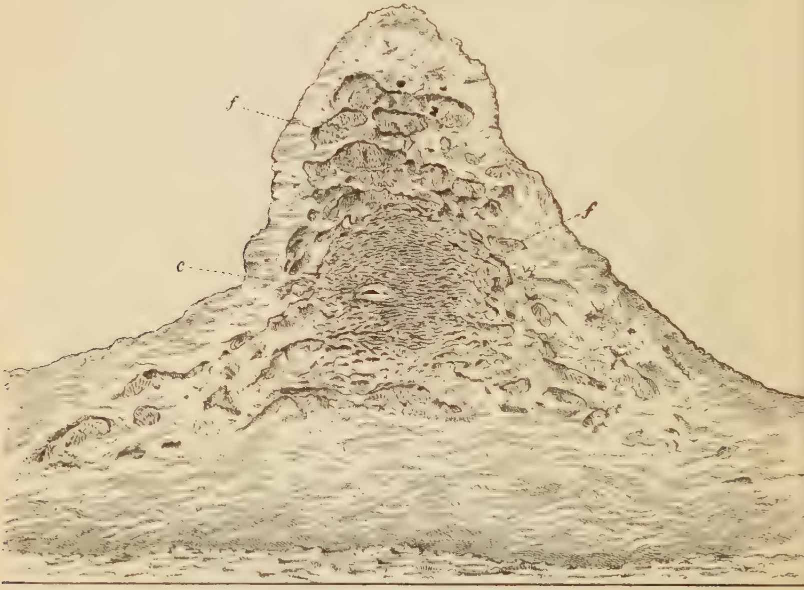
Hab. Malacca. Type, No. 503.

TERMES MALAYANUS, n. sp.

Male 14 mm. long. Castaneous above, latericious below; the epistoma, a moth-shaped mark on the pronotum, the anterior half of the mesonotum and metanotum testaceous, legs ochraceous. Ocelli large, separated from the eyes by half a diameter. Fenestra small. Antennæ of 19 segments, the 3rd not twice as long as the 2nd. Epistoma prominent. Pronotum with slightly concave posterior margin; postero-lateral margins slightly rounded, converging, posterior margin bilobed. Anterior wing-stumps but little larger than the posterior. Wings 25 mm. by 7 mm., fulvous; a line of deeper colour runs contiguous and parallel to the subcostal in the distal half of the wing; the median is at first midway between the subcostal and submedian, but soon becomes nearer to the latter, it branches at or a little beyond the middle of the wing, and once or twice again; there or 6 or 7 thick offsets from the submedian, and 4 or 5 branched slender offsets. Hind legs exceeding the abdomen. The abdominal papillæ small, their basal areas confluent.

Female with the 7th ventral plate 1·3 mm. long, 3·2 mm. broad. The abdomen of the queen enlarging to a length of 50 mm.

Soldiers: the larger 10 mm. long; head 3·3 mm. long, 2·9 mm. broad, ferruginous. An obscure white spot in the position of the eye. Fenestra perforated. Antennæ of 17 segments, the 3rd not twice as long as the 2nd. Labrum ovate, tip white, obtuse, reaching to the middle of the mandibles. Mandibles 1·8 mm., long, tip incurved, cutting-margin toothless. Gula ·8 mm. broad, nearly uniform. Pronotum with the anterior and posterior margins lobed, the lateral margins rounded. Mesonotum and



Section of nest of *Termes malayanus*, drawn from a photograph taken in Sarawak. The nest was about 6 feet high.

c. Queen's cell, surrounded by delicate laminæ of clay. *f.* Fungus-beds, occupying irregular cavities throughout the periphery of the nest.

metanotum as broad as the pronotum, the lateral margins rounded and directed slightly backward. Hind femora exceeding the apex of the abdomen. Dorsum of abdomen glabrous. Abdominal papillæ minute. The smaller soldier 5 mm. long. Head 2 mm. long, 1·7 mm. broad. Mandibles 1·5 mm. long. Pronotum 1·3 mm. broad.

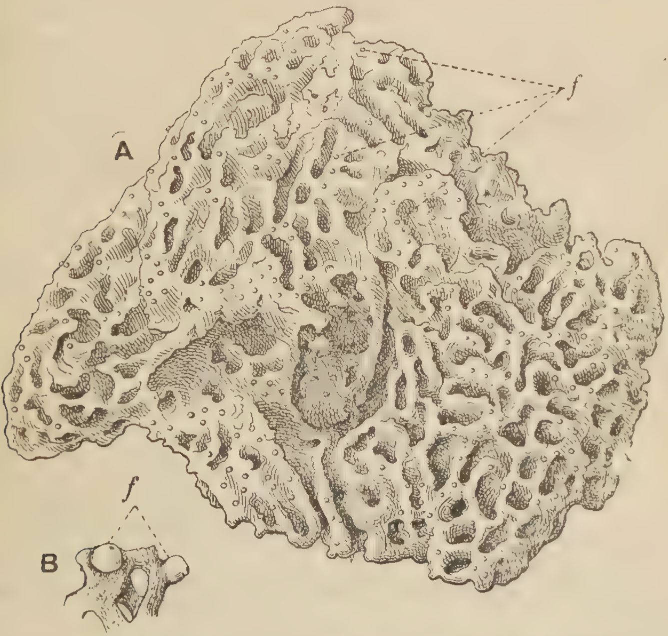
Worker 5·5 mm. long. Head to 2 mm. broad. Antennæ of 18 segments. Epistoma convex. Dorsum of abdomen arched. Abdominal papillæ well developed.

Hab. Malay Peninsula (Singapore); Borneo (Sarawak, Baram).

T. gilvus, a representative Javan species, seems distinct.

Termes natalensis, n. sp. (Pl. **23**. figs. 7–10.)

Male 19 mm. long. Above castaneous; the mandibles, epistoma, a moth-shaped mark on the pronotum, the anterior portion of the mesonotum and metanotum testaceous; below testaceous.



A. Fungus-bed from a nest of *Termes malayanus*, showing fungus-globules, nat. size. B. Small portion of the same, magnified.

Ocelli large, separated from the eye by nearly a diameter. Fenestra smaller than ocellus, rather obscure. Antennæ of 19 segments, the 3rd twice as long as the 2nd. Epistoma prominent. Pronotum subsemilunar, with concave anterior border and rounded antero-lateral corners. Anterior wing-stumps but little larger than the posterior. Hind legs exceeding the abdomen. Wing 35 mm. long, 4 mm. broad; the costal and subcostal fulvous; the latter generally gives off a posterior branch towards the apex; the median branches 2 or 3 times, the first branch is at or about

the middle of the wing; the submedian gives off 5 broad unbranched offsets, and 5 or 6 more slender branched ones. Dorsum of abdomen flat. Abdominal papillæ short and widely separate.

Female with ventral plate of 7th segment 1·5 mm. long, 4 mm. broad. The abdomen of the queen reaches a length of 60 mm.

Soldiers: the larger 13 mm. long. The head 4·7 mm. long, 4 mm. broad, ovate-quadrate, ferruginous. Eye-spot pale, very obscure. Fenestra very minute. Antennæ of 17 segments. Labrum ovate, the white tip obtuse, reaching beyond the middle of the mandibles. Mandibles 2·4 mm. long, upcurved, with piercing-tip and toothless cutting-margin. Gula ·8 mm. broad, nearly uniform. Pronotum lobed anteriorly and posteriorly, the lateral margin rounded, more sharply in front than behind. The mesonotum and metanotum nearly as broad as the pronotum, and with uniformly rounded lateral margins. Dorsum of abdomen hairy, hind femora not reaching the end of the abdomen. Abdominal papillæ present. The smaller 7 mm. long; head 3 mm. long, 2·5 mm. broad; mandibles 2 mm. long.

Worker 6 mm. long. Head castaneous, 2·6 mm. broad. Antennæ of 18 segments. Epistoma convex. Dorsum of abdomen arched. Papillæ present.

Nests forming mounds 4 feet high. Royal cell part of a large mass.

Hab. Natal.

Section with Termes vulgaris *for Type.*

Male large. Antennæ of 19 segments, the 3rd shorter than the 2nd. Fenestra absent or obscure. Epistoma prominent and rounded. The median nerve runs midway between the subcostal and submedian, and branches 3 or 4 times. The hind legs reach to the end of the abdomen. Abdomen broad.

Female with the abdomen enlarging to an enormous size. The cuticle laterally with numerous brown pigment-spots.

Soldier usually of one size only. Antennæ of 16 or 17 segments, the 2nd large, the 3rd short. Labrum with bristles, without transparent tip. Mandibles black, upcurved, with pointed incurved tip, the cutting-margin with a small tooth in the middle, more distinct upon the left side. Gula broad, narrower in the upper third. Thorax narrow, the pronotum projecting but little, the mesonotum and metanotum scarcely at all, beyond the underparts. Hind legs slender, reaching beyond the apex of the abdomen.

Worker with head chitinized and coloured. Antennæ of 17 segments. Fenestra absent.

Fungus-growers. Nest terrestrial, with scarcely any mound. Royal cell supported by delicate laminæ of clay in the middle of the nest. When the soldiers bite, they emit a milky fluid from their mouths, white or coloured.

To this section belong *T. angustatus*, *T. capensis*, and *T. taprobanes*.

Termes badius, n. sp.

Male 11 mm. long; above latericious, below pale testaceous. Ocelli large, separated from the eyes by more than a diameter. Fenestra ill-defined and small. Antennæ with the 2nd segment long, the 3rd the shortest. Epistoma prominent. Pronotum 2·7 mm. broad, semilunar, the anterior border slightly raised, the antero-lateral corners rounded. Posterior legs reaching beyond the end of the abdomen. Abdominal papillæ very minute.

Female with the abdomen reaching to a length of 70 mm., the lateral cuticle pigment-spotted.

Soldier of two sizes: the larger 10 mm. long, the head 3·6 mm. long, 3 mm. broad, ovate-quadrate, testaceous (in spirit-specimens often badious). Eye-spot pale, with pigmented centre. Fenestra absent. Antennæ of 16 or 17 segments, the 2nd long, the 3rd short. Labrum ovate on a broad base, with a few bristles near the tip, reaching to one third of the mandibles. Mandibles 1·7 mm. long, black except at the base, the tip incurved, the cutting-margin with a large tooth near the middle. Gula 1·2 mm. broad, narrow towards the apex. Pronotum 2 mm. broad, 1 mm. long, anterior portion prominent, elevated, bilobed, meeting the lobed posterior margin at a rounded angle. Mesonotum and metanotum narrower, flat, with rounded lateral margins. Hind femora reaching to the ventral plate of the 5th abdominal segment. Abdominal papillæ present. The smaller soldiers 7 mm. long; head 2·5 mm. long, 2 mm. broad, mandibles 1·4.

Worker 5 mm. long. Head ochroleucous, sometimes 2 mm. broad. Fenestra represented by an obscure pale spot. Antennæ of 18 segments, the 2nd long, the 3rd and 4th very short. Epistoma prominent. Hind legs exceeding the abdomen. Abdomen ovoid, the dorsum somewhat arched.

Fungus-growers.

Hab. Natal. Type, No. 573.

TERMES LATERICIUS, n. sp.

Male 16 mm. long, hairy, dark castaneous; mandibles, epistoma, a moth-shaped mark on the pronotum, the anterior portions of the mesonotum and metanotum testaceous; the legs and middle portions of the ventral plates umbrinous. Ocelli large, distant more than a diameter from the eyes. Antennæ of 19 segments, the 2nd longer than the 3rd. Epistoma but little prominent. Pronotum 2·7 mm. broad, semilunar, with concave anterior margin, rounded antero-lateral corners, and posterior margins slightly concave in the middle. The hind legs reach to the 7th segment of the abdomen. The anterior and posterior wing-stumps are subequal. Wings 26 mm. long, 8 mm. broad, umbrinous; a broad stain runs behind the subcostal, which gives two offsets near the apex of the wing, the first of which is branched; the median runs midway between the submedian and subcostal, and branches first in the basal quarter of the wing; the submedian gives 9 offsets, few of which are branched, it barely reaches the apical third of the wing. The abdominal papillæ are short and widely separated.

Female with the ventral plate of the 7th abdominal segment 1·3 mm. long, 3·3 mm. broad, oblong. Abdomen enlarging to a length of 70 mm., the lateral cuticle pigment-spotted.

Soldier 5 mm. long. Head 1·4 mm. long, 1·2 mm. broad, ovate, latericious in colour. Antennæ of 16 or 17 segments, the 2nd longer than the 3rd. Labrum lanceolate, tip with a few bristles, scarcely reaching the middle of the mandibles. Mandibles 9 mm. long, black at the tips, upcurved, tips incurved, cutting-margin with a tooth beyond the middle, very distinct on the left, obscure on the right. Gula ·9 mm. broad, narrower towards the apex. Pronotum 1·1 mm. broad, semilunar, with a raised convex portion on the anterior border. Mesonotum and metanotum narrower than the pronotum. Hind legs slightly exceeding the abdomen. Abdomen ovoid, coloured by the latericious contents of the salivary vesicles. Abdominal papillæ present.

Worker 5 mm. long. Head 1·5 mm. broad, latericious in colour. Antennæ of 17 segments, the 2nd longer than the 3rd. Epistoma convex. Abdomen ovoid, the dorsum slightly arched.

Fungus-growers. Nest without mound, but with one or two large passages opening on the surface of the ground.

Hab. Natal. Type, No. 79.

TERMES VULGARIS, n. sp. (Pl. 23. figs. 11–14.)

Male 14 mm. long, black, legs fuliginous, antennæ and mandibles testaceous, an obscure testaceous moth-shaped mark on the pronotum. Ocelli distant 2 diameters from the eyes. Fenestra absent. Antennæ of 19 segments, the 2nd longer than the 3rd. Epistoma convex. Pronotum 2·5 mm. broad, 1·3 mm. long, subsemilunar, anterior margin straight, antero-lateral corners obtusely rounded. Posterior margin of mesonotum and metanotum broadly concave. Anterior wing-stumps but little larger than the posterior. Wing 26 mm. long, 6·5 mm. broad; the costal and subcostal nerves thick, umbrinous; the median nerve runs nearer to the submedian than the subcostal, and gives 5 or 6 off-sets in the apical third of the wing; the submedian gives from 12 to 16 off-sets, scarcely any of which are branched. The hind leg reaches to the 8th abdominal segment. The abdominal papillæ are short and separated, and stand on white areas.

Female with the ventral plate of the 7th segment slightly broader in the middle than at the sides. Abdomen grows to a length of 50 mm.; the lateral cuticle is pigment-spotted.

Soldier 6 mm. long. Head 1·5 mm. long, 1 mm. broad, ovate, fulvous. Antennæ of 16 or 17 segments, the 2nd segment long, the 3rd the shortest. Labrum ovate, the apex with bristles, not reaching the middle of the mandibles. Mandibles 1 mm. long, testaceous at the base, castaneous towards the apex, upcurved, the tips incurved, the cutting-margin of both with a distinct tooth beyond the centre. Gula ·6 mm. broad. Pronotum semilunar, with an anterior, elevated, bilobed portion. The hind legs exceed the abdomen. The abdomen ovoid, white from the milky contents of the large salivary vesicles.

Worker 4 mm. long. Head 1·5 mm. broad, ochraceous. Antennæ of 17 segments, the 2nd long, the 3rd very short. Abdomen with the dorsum arched.

Fungus-growers. Nest with obscure mound.

Hab. Natal. Type, No. 59.

Section with Termes incertus *for Type.*

Male of moderate size, pale, subisabelline. Antennæ of 16 or 17 segments, the 2nd long, the 3rd short. Fenestra obscure. Epistoma pale, prominent. Pronotum with converging postero-lateral margins. Anterior wing-stumps but little larger than the

posterior. The median nerve runs midway between the subcostal and submedian.

Soldier with short globose head. Antennæ of 14 or 15 segments, the 2nd as long as the 3rd and 4th together. Labrum reaching beyond the middle of the mandibles. Mandibles slender, with pointed incurved tip and toothless cutting-margin. Gula as broad as long, not sunk between the sides of the head. Thorax narrow. Pronotum with raised anterior portion, the lateral corners scarcely depressed. Abdomen ovoid, as broad or broader than the head. Abdominal papillæ present.

Worker with antennæ of 14 or 15 segments, the 2nd segment long. Fenestra absent. Thorax narrow; abdomen ovoid, somewhat broader than the head.

Fungus-growers, building small fungus-beds, generally in the shells of the nests of larger species. The king and queen are not enclosed in a special royal cell.

TERMES INCERTUS, *Hagen*. (Pl. 23. figs. 15–18.)

Male 8 mm. long, pale umbrinous; pronotum and the anterior portions of the mesonotum and metanotum isabelline; epistoma, antennæ, and legs pale. Ocelli distant from the eye by half a diameter. Fenestra obscure. Antennæ of 16 segments, the 2nd long, the 3rd and 4th short. Epistoma prominent. Pronotum ·7 mm. long, 1·2 mm. broad, the anterior margin nearly straight, the postero-lateral margins somewhat convex, the posterior margin bilobed. Anterior wing-stumps but little larger than the posterior. Wing 14 mm. long, 3·5 mm. broad, pale umbrinous; the median runs midway between the submedian and subcostal, and bifurcates once or twice beyond the middle of the wing; the submedian gives off about 10 branches, one or two of which may bifurcate. The hind legs do not reach beyond the 6th segment of the abdomen. Abdominal papillæ minute.

Female with the ventral plate of the 7th segment 1 mm. long, 1·7 mm. broad. The abdomen of the queen reaches a length of 16 mm.; the lateral cuticle has minute pigment-spots and hairs.

Soldier 4 mm. long. Head ochraceous, 8 mm. long, 7 mm. broad, ovate, somewhat hairy. Antennæ of 14 segments, the 2nd large, the 3rd and 4th very small, the rest increasing in size towards the apex. Labrum lanceolate, with a few bristles near the tip, reaching $\frac{3}{4}$ of the length of the mandibles. Mandibles ·6 mm. long, narrow, slightly upcurved, tip incurved, cutting-margin toothless. Gula nearly as broad as long, not sunk between the sides of the head. Pronotum pale, with raised bilobed

anterior portion; mesonotum narrower than the pronotum. The hind legs not reaching to the end of the abdomen. Abdomen elongate ovoid, coloured at the sides by the contents of the large salivary vesicles. Abdominal papillæ present.

Worker 5 mm. long. Head ochraceous. Antennæ of 14 segments, the 2nd long, the 3rd, 4th, and 5th very short, the rest enlarging towards the apex. Thorax narrow. Abdomen oblong, hind legs not reaching to its apex.

Fungus-growers of small size. The fungus-beds are built in lenticular cavities, generally in the mounds of one of the larger species. King and queen are not enclosed in a special royal cell.

Hab. South Africa (Natal, Mozambique).

TERMES PALLIDUS, n. sp.

Nymph with antennæ of 17 segments.

Queen with chitin isabelline, the head darker. Head ovate; ocelli large, separated from the eyes by nearly a diameter. Fenestra indistinct. Antennæ with the 2nd segment as long as the 3rd and 4th together. Epistoma prominent. Pronotum with nearly straight anterior margin, with rapidly converging postero-lateral margins and short posterior margin. Abdomen 20 mm. long; the lateral cuticle minutely spotted, each spot furnished with a hair.

Soldier 4·5 mm. long. Head 1 mm. long, 1·1 mm. broad, subglobose, ochraceous, somewhat hairy. Antennæ of 15 segments, the 2nd long, the 3rd and 4th short, the rest increasing in size towards the apex. Labrum ovate, with a few bristles at the tip reaching beyond the middle of the mandibles. Mandibles 1·6 mm. long, slender, castaneous towards the apex, with sharply incurved piercing-tip and toothless cutting-margin. Gula as broad as long, not sunk between the margins of the head, and attached for less than half its length. Pronotum with semilunar posterior portion, narrow, raised, convex anterior portion. Mesonotum narrower than the pronotum. Hind legs exceeding the apex of the abdomen. Abdomen ovoid. Abdominal papillæ present.

Worker 4·5 mm. long. Head luteous. Antennæ of 15 segments, the 2nd long. Abdomen ovoid. Abdominal papillæ present.

Fungus-growers. The fungus-beds are of small size, generally in the mounds of nests of larger species. The king and queen are not enclosed in a special royal cell.

Hab. Malay Peninsula (Singapore, Malacca). Type, No. 493.

Section with Termes Gestroi *for Type.*

(This section forms the subgenus *Coptotermes* of Wasmann. It is undoubtedly a good genus.)

Male about 7 mm. long, with head convex in profile. Ocelli approximated to the eyes. Fenestra small. Antennæ of 19 segments, the 2nd large, the 3rd small. Epistoma not prominent. Pronotum large and slightly arched, with concave anterior margin. The anterior wing-stumps much larger than the posterior. Wings very hairy, the median nerve running nearer to the submedian than the subcostal; the median, the subcostal, and their branches faint. Hind legs not reaching to the apex of the abdomen. Abdominal papillæ present.

Soldier about 4 mm. long. Antennæ of 13 to 16 segments, the 2nd segment longer than the 3rd or subequal to it, the others increasing somewhat in size towards the apex. Above the epistoma there is a prominence which terminates abruptly in a large foramen, through which in life a copious viscid white secretion can be discharged. Labrum ovate, with a minute white tip scarcely reaching to the middle of the mandibles. Mandibles with incurved piercing-tip and toothless cutting-margin. Gula firmly united to the head, narrow at the base, broader towards the apex. Pronotum large, flat, slightly lobed, both anteriorly and posteriorly. Abdominal papillæ present.

Termes Gestroi, *Wasmann*.

Nymph with head convex in profile. Antennæ of 19 segments, the 2nd long, the 3rd short. Pronotum subreniform, but with antero-lateral corners prominent and rather sharply curved.

Soldier 5 mm. long. Head 1·4 mm. long, 1·3 mm. broad, suborbicular, ochroleucous, furnished with long hairs. A broad prominence above the epistoma ends in a large foramen. Antennæ of 14 to 16 segments, the 2nd larger than the 3rd, the others larger towards the apex, subglobose. Labrum lanceolate, tip white, with a few small hairs, reaching nearly to the middle of the mandibles. Mandibles ·8 mm. long, castaneous, with incurved piercing-tips and toothless cutting-margin. Gula firmly united to the head, narrow below, rapidly widening towards the apex, the free portion narrower. Pronotum large, 1 mm. broad, the anterior and posterior margins bilobed; mesonotum nearly as broad; metanotum broader. Hind legs exceeding the abdomen. Abdomen oblong, white. Abdominal papillæ rather large.

Worker 5 mm. long. Head cremeous. Antennæ of 15 or 16 segments, the 2nd large, the 3rd small, the others larger towards the apex, subspherical. Hind legs not reaching to the end of the abdomen. Abdomen oblong, white.

This species is remarkable for its habit of killing live trees. It encases the trunk, for a distance of 8 feet from the ground, with a thick crust of earth; under cover of this crust it eats through weak spots in the tree to the heart of the wood, which i excavates, forming there a kind of nest built of wood-fibre.

Hab. Malay Peninsula (Singapore); Borneo (Sarawak); Burmah.

TERMES TRAVIANS, n. sp. (Pl. 23. figs. 19–22.)

Male 7 mm. long, latericious above, fulvous below, epistoma and antennæ pale. Head ovate, convex in profile. Ocelli approximated to the eye. Fenestra small. Antennæ of 19 segments, the 2nd large, the 3rd and 4th small. Epistoma not prominent. Pronotum large, subreniform, but with antero-lateral corners prominent and sharply rounded. Anterior wing-stumps with slightly convex margin, much larger than the posterior, and slightly overlapping them at the base. Wings 10 mm. long, 3 mm. broad, hairy, the median and submedian faint; the median is unbranched, it is three times more distant from the subcostal than the submedian; the submedian gives off about 6 branches. The hind legs do not reach to the end of the abdomen. The ventral plates of the abdomen only three times broader than long. The abdominal papillæ present, small.

Female with the ventral plate of the 7th segment semicircular. The abdomen of the queen reaches a length of 27 mm.; the lateral cuticle with hairs seated on small unpigmented verrucosities; the areas of secondary chitinization large.

Soldier 4 mm. long. Head 1·3 mm. long, 1 mm. broad, ovate, ochraceous. A broad prominence above the epistoma ends in a large foramen. Antennæ of 13 or 14 segments, the 3rd sometimes larger, sometimes smaller than the 2nd, the others increasing somewhat in size towards the apex, subglobose. Labrum sublanceolate, with a few hairs at the tip, not reaching to the middle of the mandibles. Mandibles ·6 mm. long, with pointed incurved tip and toothless cutting-margin. Gula firmly united to the head, broadening towards the apex, the free portion narrower. Pronotum large, subreniform, with the antero-lateral

corners rather prominent and sharply rounded. Mesonotum much narrower than the pronotum. Hind legs exceeding the abdomen. Abdomen oblong. Abdominal papillæ present, small.

Worker 4 mm. long. Head pale, often becoming darker in spirit-specimens. Antennæ of about 13 segments; near the base they are indistinct, towards the apex subspherical. Legs not nearly reaching the end of the oblong abdomen.

This species is one of the most destructive to houses in Singapore and Sarawak.

Hab. Malay Peninsula, Borneo. Type, No. 573.

Section with Termes nasutus *for Type.*

(This section forms the subgenus *Rhinotermes* of Hagen. It is undoubtedly a good genus.)

Male broad in proportion to its length. Antennæ of 20 segments, the 3rd longer than the 2nd. Ocelli separated from the eyes by a diameter or more. Above the level of the ocelli is a minute foramen, from which a shallow groove runs down the epistoma. Epistoma prominent, above uniform with the front surface of the head, below projecting beyond the base of the labrum. Pronotum large, transversely oblong. Anterior wing-stumps much larger than the posterior, the bases of which they overlap. Wings short and broad. The median and submedian broad, but faint; there is an obscure reticulation between their branches. The median is midway between the subcostal and submedian, and branches several times. The hind legs exceed the abdomen. Abdominal papillæ present, but minute.

Soldiers of two very different sizes. The larger with broad subquadrate head. Antennæ of 16 or 17 segments, the 3rd longer than the 2nd. There is a minute foramen above the epistoma, from which a shallow groove runs to the apex of the labrum. Labrum ovate, reaching nearly to the apex of the mandibles. Mandibles large, with piercing incurved tips and large forward-directed teeth on the cutting-margins, two on the left and one on the right side. Pronotum, mesonotum, and metanotum subequal in breadth, flat and projecting slightly beyond the under-parts. Hind legs exceeding the abdomen. Abdominal papillæ present, but minute. The smaller soldiers are much more slender than the large ones.

Hagen describes two American species belonging to this section,

T. marginalis and *T. nasutus*. I describe here two new species from Borneo; the males are readily distinguished, but the soldiers and workers seem almost identical. There are specimens of soldiers and workers of other species, but in the absence of the imago it is not right to describe them.

TERMES BREVIALATUS, n. sp.

Female 8 mm. long, testaceous, wing-stumps fuliginous, antennæ pale. Head broadly ovate; in profile the epistoma is seen to project forward in the plane of the front of the head, beyond the base of the labrum, which it overhangs. Ocelli separated from the small eyes by two diameters, and placed on a level with their lower margin. There is a small foramen, from which a shallow groove runs to the end of the epistoma. Antennæ of 20 segments, the 3rd longer than the 2nd, the more distal segments globose. Pronotum ·9 mm. long, 1·6 mm. broad, transversely oblong, the postero-lateral corners more rounded than the antero-lateral ones. The posterior margins of the mesonotum and metanotum straight, not lobed. Anterior wing-stumps much larger than the posterior, which they overlap at the base. Wing 8·5 mm. long, 3 mm. broad, fuliginous, nearly glabrous. The costal and subcostal nerves are well defined, the median and submedian with their branches are but broad corrugations of the wing-membrane; there is also an intervening reticulation. The median is midway between the submedian and subcostal, and has 3 or 4 branches, the first of which is about the middle of the wing. The submedian has about 10 branches. The hind legs exceed the abdomen. The abdomen is 2·4 mm. broad. The ventral plate of the 7th segment has its posterior margin very convex. The lateral cuticle of the abdomen hairy.

Soldiers: the larger 6 mm. long, head ochraceous, antennæ, thorax, and abdomen ochroleucous. Head 1·7 mm. long, 1·5 mm. broad, subquadrate. Antennæ of 17 segments, the 3rd subequal to the 2nd, or of 16 segments, the 3rd longer than the 2nd. A minute foramen above the epistoma, from which a groove runs down to the apex of the labrum. Labrum oblong, obtuse, reaching nearly to the middle of the mandibles. Mandibles 1·2 mm. long, the tip piercing, much incurved, especially that of the right side, the cutting-margin with strong forward-pointed teeth, two on the left mandible and one on the right. Gula

firmly united to the head, narrowest at the end of the basal quarter, then broadening. Pronotum ·7 mm. long, 1·1 mm. broad, the anterior margin convex, the lateral margins sharply curved, the posterior margin broadly lobed; mesonotum as broad as the pronotum, with rounded lateral margins; metanotum rather broader. Hind legs much exceeding the abdomen, the femora reaching to the 8th abdominal segment. Abdominal papillæ present, small. The smaller soldier 4 mm. long, ochroleucous. Head 1 mm. long, ·9 mm. broad, ovate. Antennæ usually of 16 segments, the 3rd longer than the 2nd. A minute foramen above the epistoma, from which a shallow groove leads to the tip of the labrum. Labrum slightly exceeding the mandibles, bilobed at the tip. Mandibles ·7 mm. long, slender, tip incurved, margin with small forward-pointing teeth beyond the middle, two on the left and one on the right side. Gula nearly uniformly broad. Pronotum ·7 mm. broad.

Worker 5 mm. long; head white, thorax narrow, abdomen oblong. Antennæ of 16 to 17 segments. Hind legs not reaching to the end of the abdomen.

Hab. Borneo (Sarawak). Type, No. 174.

TERMES TRANSLUCENS, n. sp. (Pl. 23. figs. 23–26.)

Male 9 mm. long, testaceous above, below paler, wing-stumps pale fulvous. Head ovate, somewhat less broad than in *T. brevialatus.* In profile the epistoma is seen to project forward in the plane of the front surface of the head, beyond the base of the labrum, which it overhangs. Ocelli separated by a distance of one diameter from the eyes, which are larger than in *T. brevialatus.* There is a small median foramen, from which a shallow groove runs to the end of the overhanging epistoma. Antennæ of 20 segments, the 3rd longer than the 2nd. Pronotum 1 mm. long, 1·7 mm. broad, transversely oblong, the postero-lateral corners more rounded than the antero-lateral; mesonotum and metanotum with the posterior borders nearly straight, not lobed. Anterior wing-stumps much larger than the posterior, and covering them at the base. Wing 10 mm. long, 3·5 mm. broad, translucent in water, pale when dry. The costal and subcostal almost colourless; the median, submedian, and their branches are mere corrugations of the wing-membrane; there is an intervening network; the median is midway between the submedian and subcostal, it branches 3 or 4 times, the first branch is beyond the

middle of the wing; the submedian has 10 or 11 branches. Hind legs barely reaching the end of the abdomen. Abdominal papillæ present, small.

Female with the ventral plate of the 7th segment almost semilunar, larger than in *T. brevialatus*.

The soldiers and workers I am unable to distinguish from those of *T. brevialatus*, the description of which applies to these also.

This species is destructive to the posts of houses where they enter the ground; the posts are destroyed to a distance of a foot or two above the level of the ground.

Hab. Borneo (Sarawak). Type, No. 299.

Section with Termes æqualis *for Type.*

Nymphs with antennæ of 16 to 17 segments.

Soldier 3 to 4 mm. long. Head broad, subquadrate, flat. A minute foramen above the epistoma, from which a shallow groove runs to the apex of the labrum. Antennæ of 13 segments, the 3rd longer than the 2nd. Labrum broad, subquadrate, tip white, reaching to the end of the mandibles. Mandibles with very broad base, and narrow piercing inflexed tip; the broad base generally ends in a forward-pointing lanceolate tooth, separated from the inflexed tip by a deep interspace. Pronotum half as broad as the head, flat, with convex anterior margin and semicircular posterior margin. Mesonotum and metanotum nearly equal in breadth to the pronotum. Hind legs reaching much beyond the apex of the abdomen. Abdominal papillæ absent.

Worker from 3 to 4 mm. long. Head ochroleucous. Antennæ of 13 segments. Thorax narrowed. Hind legs not nearly reaching the apex of the abdomen. Abdominal papillæ absent.

Termes æqualis, n. sp. (Pl. **24**. figs. 27–29.)

Neoteinic queens 11 mm. long. Epistoma rather prominent, but in a plane with the front surface of the head, and not convex. Pale spots representing ocelli on a level with the lower margin of the eyes. Antennæ of 16 or 17 segments, the 2nd and 3rd subequal. Pronotum reniform.

Soldier 3·5 mm. long. Head 1 mm. long, 1 mm. broad, subquadrate, flat, ochraceous; a minute foramen above the epistoma,

from which a shallow groove runs to the apex of the labrum. Antennæ of 13 segments, the 2nd the shortest. Labrum broad, subquadrate, with white tip, reaching to the apex of the mandibles. Mandibles 5 mm. long, with broad base and narrow inflexed piercing-tips; the broad base in both mandibles ends in a lanceolate, forward-pointed tooth, separated from the inflexed tip by a deep interspace; in the left mandible there is a small second tooth at the base of the large tooth; in the right mandible the inflexed tip is thicker than in the left. Gula rather narrow at the base, but broadening in the apical two thirds. Pronotum ·6 mm. broad, with convex anterior border, sharply rounded lateral borders, and semicircular posterior border. Mesonotum and metanotum not quite as broad as the pronotum. Posterior femora reach to the 8th abdominal segment. Abdomen narrowly oblong. Abdominal papillæ absent.

Worker 3·5 mm. long. Head ochroleucous. Antennæ of 13 segments, the 2nd and 3rd subequal. Thorax narrowed. Hind legs not nearly reaching to the apex of the abdomen. Abdomen oblong. Abdominal papillæ absent.

Hab. Borneo (Sarawak). Type, No. 295.

No. 392 seems to be identical with this in every respect, except that both workers and soldiers are one-fifth smaller in all their measurements.

TERMES INÆQUALIS, n. sp.

Nymph with antennæ of 16 segments, the 2nd segment long, the 3rd short. Epistoma convex, slightly prominent.

Soldier 4 mm. long. Head 1·4 mm. long, 1·2 mm. broad, subcordate, flat, latericious in colour. There is a minute foramen above the epistoma, from which a shallow groove runs to the apex of the labrum. Antennæ of 13 segments, the 3rd longer than the 2nd. Labrum broad, subquadrate, with white tip, reaching nearly to the apex of the mandibles. Mandibles ·6 mm. long, with broad base and narrow, piercing, inflexed tips; in the left mandible the broad base ends in a large, broadly lanceolate, forward-pointed tooth, which is separated from the inflexed tip by a deep space; in the right mandible the broad base ends abruptly, but is not separated from the inflexed tip by any interspace. Gula narrow, narrowest at the end of the basal third, then broadening. Pronotum ·7 mm. broad, with convex anterior margin, sharply rounded lateral margins, and uniformly

rounded posterior margins. Metanotum as broad as the pronotum, mesonotum slightly narrower. Hind femora reaching nearly to the apex of the abdomen. Abdomen oblong. Abdominal papillæ absent.

Worker 4 mm. long. Head ochroleucous. Antennæ of 13 segments, the 2nd long. Thorax narrow. Hind legs not reaching to the end of the abdomen. Abdomen elliptic oblong. Abdominal papillæ absent.

Hab. Borneo (Sarawak). Type, No. 365.

Section with Termes planus *for Type.*

Male $3\frac{1}{2}$ mm. long, flat. Head subtriangular. Antennæ of 15 segments, the 2nd longer than the 3rd. Epistoma not prominent. Pronotum half as broad as the head, with a median anterior spinous process. Anterior wing-stumps larger than the posterior, but not overlapping them. Wings short, hairy, the median nerve invisible. Abdominal papillæ absent.

Soldier 4 mm. long, flat. Head cordate. Foramen absent. Antennæ of 14 segments, the 2nd longer than the 3rd. Labrum lanceolate, reaching beyond the middle of the mandibles. Mandibles curved, with pointed tip and toothless cutting-margin. Pronotum small, with median anterior spinous process. Abdominal papillæ absent.

Termes planus, n. sp. (Pl. 24. figs. 30–33.)

Male 3 mm. long, much flattened, castaneous above, fulvous below. Head ·8 mm. broad, subtriangular, hairy. Fenestra obscure, situated near the broad vertex. Ocelli one diameter distant from the small eyes. Antennæ of 15 segments, the 2nd longer than the 3rd, the others increasing slightly in size towards the apex. Epistoma not prominent. Pronotum small, half as broad as the head, the anterior border with a median forward-pointing spine, the posterior border uniformly convex. Posterior borders of mesonotum and metanotum straight, scarcely lobed. Anterior wing-stumps larger than the posterior, but not overlapping them. Wing 4·5 mm. long, 1·5 mm. broad, hairy, uliginous, the costal and subcostal nerves well developed; the median nerve is invisible, the submedian is faint, but has 6 or 7 offsets. The hind legs reach the 7th segment of the abdomen. Abdominal papillæ absent.

Queen 6 mm. long, the abdomen much flattened. The lateral cuticle with long hairs but no pigment-spots.

Soldier 4 mm. long. Head 1 mm. long, 1·2 mm. broad, cordate, very flat, ochraceous, hairy. Foramen absent. Antennæ of 14 segments, the 3rd very short, the 2nd longer than the 4th. Labrum lanceolate, acute, reaching nearly to the tip of the mandibles. Mandibles ·7 mm. long, tip slightly incurved, the cutting-margin toothless. Gula narrow at the base, broadening considerably towards the apex. Pronotum half as broad as the head, the anterior margin convex with a short median process, the posterior margin uniformly convex. Mesonotum and metanotum broader than the pronotum. Posterior femora much dilated; the hind legs sometimes exceed the abdomen. Abdomen oblong. Abdominal papillæ absent.

Worker 4 mm. long, flattened. Head ochroleucous, subtriangular. Antennæ of 14 segments, the 2nd long. Pronotum small, half as broad as the head. Mesonotum and metanotum broader than the pronotum. Femora dilated. Abdomen elongate.

Hab. Borneo (Sarawak). Type, No. 164.

Section with Termes tenuis *for Type.*

Imago 5 mm. long, slender, umbrinous above. Head convex in profile. Fenestra obscure. Four obscure pale spots form a curve between the eyes. Antennæ of 15 to 17 segments, the 2nd long, the 3rd very short. Pronotum with shortly bilobed anterior margin, converging lateral margins, and obscurely lobed posterior margin. Anterior wing-stumps larger than the posterior, but not overlapping them. Wings more than 4 times as long as broad; the faint median takes a straight unbranched course to the apex of the wing; the submedian also runs to the apex of the wing. Abdominal papillæ present.

Soldier 4 mm. long; head ochraceous, thorax and abdomen milk-white. Head about 1·3 mm. long, ·8 mm. broad, prominent in profile above the level of the antennæ. Antennæ of 13 to 15 segments. Labrum lanceolate acute, reaching to the middle of the mandibles. Mandibles slender, nearly straight, with slightly incurved piercing-tip and toothless cutting-margin. Gula narrow in the lower half, broadening rapidly in the upper half. Pronotum with bilobed anterior margin. Abdominal papillæ present.

TERMES TENUIOR, n. sp. (Pl. 24. figs. 34–37.)

Male 5 mm. long, slender, umbrinous above, pale below, legs and antennæ pale. Head short, ovate, convex in profile. Ocelli approximated to the eyes. Fenestra very obscure. Four obscure pale spots form a curve nearly on a level with the ocelli. Antennæ of 15 segments, the 2nd longer than the 3rd, the others increasing in size towards the apex. Epistoma scarcely prominent. Pronotum with anterior margin slightly bilobed, lateral margins rapidly converging, and posterior margins obscurely lobed. The posterior margins of the mesonotum and metanotum narrow. Anterior wing-stumps much larger than the posterior, but not overlapping them. Wings 6·5 mm. long, 1·6 mm. broad, hairy, avellaneous; the faint median runs midway between the submedian and subcostal, taking a straight unbranched course to the apex of the wing; near the end of the subcostal, the submedian is faint and runs to the apex of the wing, it gives off about 11 branches. The hind legs do not reach the apex of the abdomen. Abdomen slender, hairy. Abdominal papillæ present, but minute.

Female with the ventral plate of the 7th abdominal segment long, with parabolic posterior margin.

Soldier 4 mm. long; mandibles dark, head ochraceous; thorax and abdomen milk-white. Head 1·3 mm. long, ·8 mm. broad, in profile prominent above the level of the antennæ. Antennæ of 13 segments, the 2nd sometimes longer, sometimes shorter than the 3rd. Labrum lanceolate acute, reaching to the middle of the mandibles. Mandibles ·8 mm. long, narrow, the pointed tip slightly incurved, the cutting-margin toothless. Gula narrow in the basal half, broadening rapidly in the apical half. Pronotum nearly as long as broad, with bilobed anterior margin, converging lateral margins, and slightly lobed posterior margin. Hind legs not reaching to the end of the abdomen. Abdomen rather slender. Abdominal papillæ present.

Worker 3·5 mm. long. Head stramineous. Antennæ of 13 segments, the 2nd long, the 3rd very short. Pronotum subsemilunar. Abdomen fusiform.

Hab. Borneo (Sarawak). Type, No. 418.

TERMES TENUIS, *Hagen.*

Male 5·5 mm. long, slender, isabellinous. Head ovate, in profile prominent between the eyes. Ocelli absent. Fenestra

present, with a pale area above it. Four obscure pale spots form a curve between the eyes. Antennæ of 17 segments. the 2nd longer than the 3rd, which is small. Epistoma not prominent. Pronotum ·5 mm. long, ·8 mm. broad, with bilobed anterior margin, converging lateral margins, and obscurely lobed posterior margin. Anterior wing-stumps much larger than the posterior, but scarcely overlapping them. Wings 9 mm. long, 2·2 mm. broad, avellaneous, hairy; the median is faint and takes an almost straight course to the apex of the wing, sometimes it bifurcates near the end; the submedian is faint and reaches the margin of the wing a little behind the apex. Hind legs reach nearly to the apex of the abdomen. Abdominal papillæ present, slender.

Female with the ventral plate of the 7th segment semilunar.

Soldier 5 mm. long. Head 1·7 mm. long, 1 mm. broad, ochroleucous, narrowed abruptly just above the level of the antennæ. Antennæ of 15 segments, the 2nd longer than the 3rd, which is short. Labrum ovate, obtuse, reaching to a quarter of the length of the mandibles. Mandibles 1 mm. long, slender, nearly straight, the pointed tips slightly incurved, the cutting-margin toothless, that of the left somewhat serrate at the base. Gula narrow at the base, broadening somewhat towards the apex. Pronotum large, subreniform, the anterior margin bilobed, the posterior margin obscurely lobed. Thorax and abdomen white. Hind legs exceeding the abdomen. Abdominal papillæ slender.

Worker 4·5 mm. long. Head white. Antennæ of 15 segments.

Hab. Brazil; W. Indies; St. Helena.

This species is very destructive to buildings. It is peculiar in having no ocelli. The specimens here described were from Trinidad, collected by Mr. Hart.

Section with Termes dubius *for Type.*

Male 5 to 6 mm. long, slender. Head ovate. Fenestra absent. Antennæ of 14 segments, the 2nd longer than the 3rd, which is very short. Epistoma convex and prominent. The anterior margin of the pronotum nearly straight and slightly everted. The posterior margins of the mesonotum and metanotum short and more or less concave. The anterior wing-stumps a little larger than the posterior. Wings 6 to 7·5 mm. long, umbrinous, shortly hairy; the faint median runs much

nearer to the submedian than the subcostal, it reaches the apex of the wing, and may have one or two offsets; the submedian is faint and reaches to within an eighth of the apex of the wing, it has from 8 to 12 offsets. The hind legs do not reach the apex of the abdomen. The abdominal papillæ are very minute.

Female with the ventral plate of the 7th abdominal segment half as long as broad, the posterior margin rather prominent near middle, where it may be obscurely bilobed.

Soldier 4 to 6 mm. long. Head subcylindric, about 1·5 mm. long, 1 mm. broad. Antennæ of 13 segments, the 2nd longer than the 3rd. Labrum subovate, entire, not reaching to a third of the mandibles. Mandibles rather slender, more or less curved, especially near the piercing-tips, the cutting-margin more or less minutely serrate. Gula long, rather broader in the apical half. Pronotum small, saddle-shaped. Hind legs reaching to the end of the abdomen. Abdomen coloured by the intestinal contents. Abdominal papillæ minute.

Worker 3·5 to 5 mm. long. Antennæ of 13 segments, the 3rd and 4th very short. Abdomen ovoid, coloured by the intestinal contents.

The nests may be built of wood-fibre on the trunks of trees, or of earthy material on the surface of the ground. These termites are very sluggish in their movements. The species seems to be very numerous and very difficult to distinguish.

TERMES DISTANS, n. sp.

Male 5·5 mm. long. Head and pronotum black, the dorsal plates of the abdomen castaneous, the posterior halves of the mesonotum and metanotum and the lateral ends of the ventral plates of the abdomen fuliginous, the anterior halves of the mesonotum and metanotum, the legs, and the middle of the ventral plates of the abdomen umbrinous. Head ovate, the ocelli separated from the eyes by more than a diameter. Fenestra absent. Antennæ of 14 segments, the 2nd larger than the 3rd, which is very small, the others increasing in size somewhat towards the apex. Epistoma convex and prominent. Pronotum with anterior margin straight, scarcely raised; antero-lateral sharply rounded, not depressed; lateral margins nearly straight, converging; posterior margin obscurely bilobed. Posterior margins of mesonotum and metanotum slightly concave.

Anterior wing-stumps slightly larger than the posterior. Wings 7·4 mm. long, 2 mm. broad, hairy, umbrinous; the very faint median runs nearer the submedian than the subcostal, and reaches the apex of the wing, giving one offset; the faint submedian reaches to an eighth of the apex of the wing and gives eight offsets The hind legs do not nearly reach the apex of the abdomen. The abdominal papillæ very minute.

Female with the ventral plate of the 7th abdominal segment half as long as broad. The abdomen of the queen reaches a length of 30 mm.; the lateral cuticle has small pigment-spots and hairs.

Soldier 6 mm. long. Head 1·7 mm. long, 1·1 mm. broad, latericius. Antennæ of 13 segments, the 2nd larger than the 3rd, which is small. Labrum ovate, reaching to one third of the mandibles. Mandibles 1 mm. long, slender, curved, especially near the tips, the cutting-margin minutely serrate. Pronotum saddle-shaped, the anterior portion bilobed, raised. Hind legs reaching to the end of the abdomen. Abdomen oblong. Abdominal papillæ minute.

Worker 4·5 mm. long. Head pale or subcastaneous. Antennæ of 13 segments. The abdomen coloured by the intestinal contents.

Hab. Borneo; Sulu Islands; Celebes. Type, No. 578.

TERMES DUBIUS, n. sp. (Pl. 24. figs. 38–41.)

Male 5·5 mm. long, slender, castaneous above, fuliginous below. Head ovate. Ocelli separated from the eyes by less than a diameter. Fenestra absent. Antennæ of 14 segments, the 2nd large, the 3rd very small, the others increasing somewhat towards the apex. Epistoma slightly prominent and convex. Pronotum subsemilunar, the anterior margin nearly straight, slightly everted, the antero-lateral corners rounded, slightly deflexed. The mesonotum and metanotum with the posterior margins short and concave. Front wing-stumps a little larger than the hind ones. Wings 7 mm. long, 2 mm. broad, fuliginous, hairy; the faint median runs nearer the submedian than the subcostal, it reaches the apex of the wing, and gives one or two offsets in the apical quarter; the submedian is faint, it reaches to an eighth from the apex of the wing and gives about 9 offsets. The hind legs do not reach the apex of the abdomen. Abdominal papillæ minute.

Female with the ventral plate of the 7th abdominal segment half as long as broad, the posterior margin obscurely lobed. The

abdomen of the queen reaches 25 mm., the lateral cuticle with minute pigment-spots and hairs.

Soldier 4·5 mm. long. Head ochraceous, 1·4 mm. long, 1 mm. broad. Antennæ of 13 segments, the 2nd longer than the 3rd. Labrum reaching to a fifth of the length of the mandibles. Mandibles 1·1 mm. long, slender, curved through their whole length; the cutting-margin minutely serrate. Gula long, slightly broader in the apical half. Pronotum saddle-shaped, very short. Hind legs reaching to the end of the abdomen. Abdominal papillæ very minute.

Worker 4 mm. long. Head ochroleucous. Antennæ of 13 segments, the 3rd and 4th very short. The abdomen oblong, discoloured by the intestinal contents.

Hab. Borneo. Type, No. 577.

TERMES SERRATUS, n. sp.

Female 5·5 mm. long, slender, castaneous above, fuliginous below, tarsi pale. Head ovate. Eyes and ocelli moderately large, separated by half the diameter of an ocellus. Fenestra absent. Antennæ of 14 segments, the 2nd longer than the 3rd, which is very small, the others subglobose, increasing considerably in size towards the apex. Epistoma slightly convex and prominent. Pronotum with the anterior margin nearly straight, slightly everted, antero-lateral corners scarcely deflexed; lateral margins nearly straight, converging into the distinctly concave posterior margin. Mesonotum and metanotum with the posterior margin short, but deeply concave. Anterior wing-stumps but little larger than the posterior. Wings 7·2 mm. long, 1·8 mm. broad, hairy, pale umbrinous; a stain behind the subcostal; the median rather faint, it runs to the apex of the wing and gives one offset at a quarter from the apex, and a second further on; the submedian, rather faint, gives 11 offsets. Hind legs reach to the 6th segment of the abdomen. Ventral plate of the 7th segment half as long as broad, the posterior margin obscurely lobed towards the middle.

Soldier 4·5 mm. long. Head 1·6 mm. long, 1 mm. broad, ochraceous. Antennæ of 13 segments, the 2nd longer than the 3rd, which is very short. Labrum ovate obtuse, reaching to a third of the length of the mandibles. Mandibles ·8 mm. long, slightly curved, especially towards the tips; the cutting-margin minutely serrate, especially on the left. Gula rather long,

narrow in the basal third, broadening towards the apex. Pronotum small, saddle-shaped; the anterior portion much elevated, the posterior portion short. Hind legs not reaching to the end of the abdomen. Abdominal papillæ very minute.

Worker 3·5 mm. long. Head ochroleucous. Antennæ of 13 segments, the 2nd larger than the 3rd, which is small. Abdomen oblong, coloured by the intestinal contents.

Hab. Borneo. Type, No. 364.

TERMES PARVUS, n. sp.

Male 4·5 mm. long, slender, castaneous above, tarsi pale, ventral plates of abdomen fuliginous at the sides, pale in the middle. Head ovate. Eyes and ocelli small, ocelli separated from the eyes by more than a diameter. Fenestra absent. Antennæ of 14 segments, the 2nd longer than the 3rd, which is short, the others increasing a little in size towards the apex. Epistoma slightly convex and prominent. Pronotum with anterior margin nearly straight, the antero-lateral corners deflexed, lateral margins rounded, converging into the obscurely lobed posterior margin. Mesonotum and metanotum with posterior margins short and nearly straight. Front wing-stumps but little larger than the hind ones. Wing 6 mm. long, 1·6 mm. broad, pale umbrinous; the median nerve is faint, it runs much nearer the submedian than the subcostal, it reaches the apex of the wing and bifurcates a little before the end; the submedian is faint, it reaches to one-eighth from the apex of the wing, and has 9 or 10 offsets. The hind legs reach to the 5th segment of the abdomen. Abdominal papillæ very minute.

Female with the ventral plate of the 7th segment large, semicircular, with two small posterior lobes. The abdomen of the queen 10 mm. long, rather narrow.

Soldier 4 mm. long. Head 1·3 mm. long, ·8 mm. broad, ochraceous. Antennæ of 13 segments, the 2nd longer than the 3rd, which is very short. Labrum ovate obtuse, reaching to one-third of the length of the mandibles. Mandibles ·8 mm. long, slender, straight in the basal part, curved towards the tip, cutting-margin minutely serrate. Gula long, a little broader in the apical half. Pronotum saddle-shaped; the anterior portion short. Abdomen oblong, coloured by the intestinal contents. Hind legs not reaching to the end of the abdomen. Abdominal papillæ very minute.

Worker 3·5 mm. long. Head ochroleucous. Antennæ of 13 segments, the 3rd very small. Abdomen oblong, coloured by the intestinal contents.

Nest, on the surface of the ground, of dark earthy material.

Hab. Natal. Type, No. 29.

Section with Termes sulphureus *for Type.*

Male about 6 mm. long. Head ovate. Fenestra present. Antennæ with the 2nd segment longer than the 3rd. Epistoma convex and prominent. Pronotum with nearly straight anterior margin. Anterior wing-stumps considerably larger than the posterior. Abdominal papillæ very minute.

Female with the ventral plate of the 7th segment not half as long as broad, the lateral cuticle of the abdomen in the queen not pigment-spotted.

Soldier 4·5 mm. long. Head subglobose. Antennæ of 14 segments, the 2nd longer than the 3rd or 4th. Labrum ovate, not reaching to the middle of the mandibles. Mandibles slender, much incurved towards the pointed tips, the cutting-margin with a small transverse tooth about the middle. Gula scarcely twice as long as broad, united to the head near the base only. Pronotum saddle-shaped, short, the anterior portion convex, not bilobed, the lateral angles much depressed. Hind legs not reaching to the end of the abdomen. Abdomen large ovoid, much broader than the head, the dorsum arched, laterally coloured by the contents of the large salivary vesicles. Abdominal papillæ minute.

Worker 4·5 mm. long. Fenestra absent. Antennæ of 14 segments, the 3rd and 4th small. Epistoma convex and prominent. Abdomen coloured by the intestinal contents.

Termes sulphureus, n. sp. (Pl. 24. figs. 42–44.)

Male 6 mm. long, pale castaneous above, the mesonotum, metanotum, and a moth-shaped mark on the pronotum subisabelline, below pale umbrinous. Head ovate. Ocelli separated from the eyes by less than a diameter. Fenestra present, small. Antennæ with the 2nd segment larger than the 3rd, the 4th larger than the 5th. Epistoma pale, convex, prominent. Pronotum 1 mm. broad, the anterior margin nearly straight, the antero-lateral angles somewhat depressed, the lateral margins converging, convex, the posterior margin obscurely bilobed.

Mesonotum and metanotum with the posterior margins shortly bilobed. Anterior wing-stumps considerably larger than the posterior, but not overlapping them. Hind legs not reaching to the end of the abdomen. Abdominal papillæ very minute.

Female with the ventral plate of the 7th abdominal segment not half as long as broad, the posterior margin convex. The abdomen of the queen reaches a length of 30 mm.; secondary chitinization is almost absent; the lateral cuticle smooth, without pigment-spots, and with very short hairs.

Soldier 4·5 mm. long. Head 9 mm. long, 1 mm. broad, subglobose, ochraceous. Antennæ of 14 segments, the 2nd longer than the 3rd or 4th. Labrum ovate, not reaching to the middle of the mandibles. Mandibles ·9 mm. long, very slender, much incurved towards the piercing-tip, the cutting-margin with a small transverse tooth near the middle. Gula scarcely twice as long as broad, united to the head near the base only. Pronotum saddle-shaped, short, the lateral angles much depressed, the anterior margin raised, convex, not bilobed. The hind legs do not reach the apex of the abdomen. Abdomen ovoid, large, broader than the head, the dorsum arched, coloured yellow by the contents of the large salivary vesicles. Abdominal papillæ minute.

Worker 4·5 mm. long. Head ochroleucous. Fenestra absent. Antennæ of 14 segments, the 3rd and 4th small. Epistoma convex, prominent. Abdomen oblong, coloured by the intestinal contents.

Nests forming large mounds 4 or 5 feet high.

Hab. Malay Peninsula (Perak), (Selangor), (Malacca). Type, No. 117.

Section with Termes dentatus *for Type.*

Male 5 to 6 mm. long. Head ovate. Antennæ of 15 segments, the 2nd longer than the 4th, the 3rd variable in length. Epistoma more or less convex and prominent. Pronotum with nearly straight anterior margin, and slightly deflexed antero-lateral angles. Wings 8·9 mm. long, the median nearer to the submedian than the subcostal, and reaching to the apex of the wing. Anterior wing-stumps slightly larger than the posterior. Abdominal papillæ absent.

Female with the ventral plate of the 7th abdominal segment about half as long as broad.

Soldier 4·5 mm. long. Head ovate. Antennæ of 14 segments, the 2nd longer than the 4th, the 3rd variable in length. Labrum entire, ovate, not reaching to the middle of the mandibles. Mandibles strong, incurved, with piercing-tip, the cutting-margin with or without a strong tooth. Gula broad and short. Pronotum short, saddle-shaped.

Worker 4 mm. long. Head small. Antennæ of 14 segments. Fenestra absent. Epistoma convex and prominent. Thorax narrower than the head. Abdomen large, ovoid, coloured by the intestinal contents.

TERMES MIRABILIS, n. sp.

Male 5·5 mm. long, stout, subisabelline, head and pronotum umbrinous, beneath pale. Head ovate. Ocelli approximated to the eyes, which are large. Fenestra absent. Antennæ of 15 segments, the 3rd subequal to but longer than the 2nd, the 4th shorter than the 2nd. Epistoma scarcely prominent. Pronotum with straight anterior margin, the antero-lateral angles sharply rounded, slightly depressed, the lateral margins converging, convex, the posterior margin bilobed. The posterior margins of the mesonotum and metanotum rather acutely lobed. Anterior wing-stumps a little larger than the posterior. Wings 8·5 mm. long, 2·5 mm. broad, pale umbrinous, hairy; the median runs much nearer the submedian than the subcostal, it reaches the apex of the wing, and gives one offset in the apical fifth of the wing; the submedian reaches to the apical tenth of the wing and gives about 8 offsets. The hind legs reach to the apex of the abdomen. The abdomen broad. Abdominal papillæ absent.

Female with the ventral plate of the 7th abdominal segment half as long as broad, its posterior portion uniformly rounded. The abdomen of the queen reaches a length of 18 mm., it is much distended; secondary chitinization almost absent; the lateral cuticle of the abdomen without pigment, but with very minute hairs.

Soldier 5·5 mm. long. Head 1·3 mm. broad, ovate, ochroleucous. Antennæ of 14 segments, the 2nd shorter than the 3rd, longer than the 4th. Labrum ovate, short, not reaching to a quarter of the length of the mandibles. Mandibles 1 mm. long, rather broad in the broad part, the piercing-tip sharply incurved, the cutting-margin toothless, but with two or three serrations near the base. Gula ovate, not sunk between the

margins of the head. Pronotum short, saddle-shaped, the convex anterior margin raised, scarcely lobed, the lateral angles not depressed. Hind legs exceeding the abdomen. Abdomen ovoid, as broad as the head, dorsum arched, the intestinal contents dark. Abdominal papillæ absent.

Worker 4 mm. long. Head pale. Antennæ of 14 segments. Fenestra absent. Epistoma convex, prominent. Abdomen dark from intestinal contents.

Hab. Malay Peninsula (Singapore); Borneo (Sarawak), (Mt. Lambir). Type, No. 469.

TERMES DENTATUS, n. sp. (Pl. 24. figs. 45-48.)

Male 6 mm. long, subcastaneous above, mesonotum and metanotum paler, beneath subumbrinous. Head ovate, the ocelli separated from the eyes by half a diameter. Fenestra absent. The antennæ of 14 segments, the 2nd slightly longer than the 4th, but shorter than the 3rd. Epistoma scarcely prominent. Pronotum with straight anterior margin, antero-lateral angles rounded, depressed, the postero-lateral margins converging, the posterior margin broadly lobed. Mesonotum and metanotum with the posterior margins narrow and somewhat acutely lobed. The anterior wing-stumps but little larger than the posterior. Wing 8 mm. long, umbrinous, the subcostal nerve stout; the median runs much nearer the submedian and the subcostal, it reaches the apex of the wing and gives two offsets; the submedian reaches to an eighth of the apex and gives about 7 offsets. The hind legs reach to the 6th abdominal segment. Abdominal papillæ absent.

Female with the ventral plate of the 7th abdominal segment not half as long as broad, the posterior margin broadly rounded, with two small pale spots near the middle. In the queen the abdomen reaches a length of 25 mm., it is much distended; secondary chitinization absent, the lateral cuticle with well-marked pigment-spots and short hairs.

Soldier 5 mm. long. Head 1·2 mm. broad, ochraceous, convex in front above the level of the antennæ. Antennæ of 14 segments, the 2nd longer than the 4th, subequal to the 3rd. Labrum ovate, reaching to a third of the mandibles. Mandibles ·7 mm. long, strongly incurved, with piercing-tip, the cutting-margin with a narrow transverse tooth about the middle. Gula oblong, nearly twice as long as broad, firmly united to the head.

Thorax narrow. Pronotum saddle-shaped, the anterior portion short, much elevated, convex. The hind legs do not reach to the apex of the abdomen. The abdomen fusiform, coloured by the intestinal contents. Abdominal papillæ absent.

Worker 4·5 mm. long. Head small, pale. Antennæ of 14 segments. Fenestra absent. Epistoma convex, prominent. Abdomen large, coloured by the intestinal contents.

Hab. Borneo (Sarawak), (Marudi). Type, No. 535.

TERMES GLOBOSUS, n. sp.

Male 4·5 mm. long, dark castaneous. Head ovate. Ocelli separated from the eyes by less than a diameter. Fenestra absent. Antennæ of 15 segments, the 3rd very short, the 2nd longer than the 4th or 5th. Epistoma scarcely prominent. Pronotum with the anterior margin straight, slightly raised, the antero-lateral corners scarcely depressed, the posterior margin shortly lobed. Mesonotum and metanotum with the posterior margins nearly straight. Anterior wing-stumps somewhat larger than the posterior. Wings 7·5 mm. long, the subcostal nerve thick; the median runs much nearer the submedian than the subcostal, it reaches the apex of the wing and branches in the apical third; the submedian reaches to a sixth from the apex of the wing and has about 9 offsets. The hind legs reach to the 5th segment of the abdomen. Abdominal papillæ absent.

Female with the ventral plate of the 7th abdominal segment quite half as long as broad, the posterior margin obscurely lobed.

Soldier 3·5 mm. long. Head 1 mm. broad, subglobose, fulvous. Antennæ of 14 segments, the 2nd long, the 3rd and 4th very short. Labrum ovate, reaching to a third of the length of the mandibles. Mandibles ·8 mm. long, much curved, with sharp piercing-tips, the cutting-margin with a strong barb-like tooth about the middle. Gula very short, scarcely longer than broad. Pronotum saddle-shaped, the anterior lobe raised, not bilobed. Hind legs reaching to the end of the abdomen. Abdomen white, subglobose. Abdominal papillæ absent.

Worker 4 mm. long. Head ochroleucous. Antennæ of 14 segments. Epistoma a little prominent. Abdomen fusiform, coloured by the intestinal contents.

Hab. Borneo (Mt. Lambir). Collected by C. Hose, Esq.

TERMES HASTATUS, n. sp.

Male 5 mm. long, slender, dark castaneous, the head and pronotum almost black, the tarsi and ventral plates of the abdomen pale. Head ovate. Ocelli separated from the small eyes by half a diameter. Fenestra small. Antennæ of 15 segments, the 2nd longer than the 3rd, 4th, or 5th. Epistoma convex and prominent. Pronotum with the anterior margin nearly straight, the antero-lateral corners depressed, the posterior margin not lobed. Mesonotum and metanotum narrow, the posterior margins obtusely lobed. Anterior wing-stumps but little larger than the posterior. Wings 9 mm. long; the median nerve arises from the subcostal even in the anterior of the wing, it runs much nearer the submedian than the subcostal, it is faint, but reaches the apex of the wing and gives two offsets, one in the middle of the wing and one near the apex; the submedian reaches a third from the apex of the wing, and has 5 or 6 offsets. The hind legs do not reach to the apex of the abdomen. Abdominal papillæ absent.

Female with the ventral plate of the 7th abdominal segment half as long as broad. The abdomen of the queen reaches to a length of 15 mm.; it is not much swollen.

Soldier 4 mm. long. Head 1·3 mm. long, 1·1 mm. broad, ochroleucous. Antennæ of 14 segments, the 2nd longer than the 4th, the 3rd rather variable. Labrum reaching to one third of the length of the mandibles. Mandibles ·7 mm. long, much curved, the tips piercing, the cutting-margin with a barb-like tooth about the middle. Gula nearly uniform in breadth, not sunk between the margins of the head. Pronotum saddle-shaped, the anterior portion large, convex, not much elevated. Hind legs slightly exceeding the abdomen. Abdomen ovoid, with the dorsum arched, coloured by the intestinal contents. Abdominal papillæ absent.

Worker 3·5 mm. long. Head ochraceous. Antennæ of 14 segments. Thorax narrow. Abdomen ovoid, with the dorsum arched, coloured by the intestinal contents.

Hab. S. Africa (Cape), (Port Elizabeth). Type, No. 21.

Section with Termes bilobatus *for Type.*

Male 5 mm. long. Head ovate. Antennæ of 15 segments, the 2nd large, the 3rd small. Epistoma prominent. Pronotum semilunar. Mesonotun and metanotum with the posterior

margins narrow and with small acute lobes. Wing with the median nerve faint, running nearer to the submedian than the subcostal, and branching 3 or 4 times in the apical half of the wing. Abdominal papillæ absent.

Soldier 6 mm. long. Head 1·5 mm. broad, with large median rounded protuberance above the level of the antennæ. Antennæ of 14 (often 15) segments, the 2nd longer than the 3rd. Labrum with two long diverging lobes reaching to a third of the length of the mandibles. Mandibles slender, tapering gradually from the base, moderately curved, the cutting-margin toothless. Pronotum saddle-shaped. Abdomen ovoid acute. Abdominal papillæ absent.

To this section belongs *T. destructor.*

Termes bilobatus, n. sp. (Pl. 24. figs. 49–52.)

Male 5·5 mm. long, stout, dark castaneous, tarsi umbrinous. Head ovate. Eyes prominent. Ocelli separated from the eyes by a diameter. Fenestra present. Antennæ of 15 segments, the 2nd large, the 3rd and 4th small. Epistoma convex and prominent. Pronotum 1 mm. broad, semilunar, the anterior margin slightly concave, the antero-lateral corners rather sharp, slightly depressed. The posterior borders of the mesonotum and metanotum very narrow, shortly but acutely lobed. Anterior wing-stumps subequal to the posterior. Wings 11·5 mm. long; the median, which is faint, runs nearer the submedian than the subcostal; it reaches the apex of the wing and gives off two or three branches in the apical half; the submedian reaches to a third from the apex of the wing and has 8 offsets. The hind legs reach to the apex of the abdomen. The abdominal papillæ are absent.

Female with the ventral plate of the 7th abdominal segment half as long as broad, the postero-lateral margins meeting in the middle to form a rounded obtuse angle. The abdomen of the queen reaches to 15 mm., and is not much distended.

Soldier 6·5 mm. long. Head 1·5 mm. broad, aurantiacous, oblong; there is a large median rounded protuberance just above the level of the antennæ. Antennæ of 14 segments, the 2nd somewhat longer than the 3rd or 4th. Labrum with two long diverging lobes which reach to a third of the length of the mandibles. Mandibles 1·5 mm. long, rather slender, and tapering gradually to the tip, curved slightly at the base, but more so towards the apex, the cutting-margin toothless. Gula oblong,

firmly united to the head, but not sunk between its sides. Pronotum short, saddle-shaped, the anterior portion convex, slightly elevated. Hind legs reaching to the apex of the abdomen. Abdomen ovoid, acute, coloured by the intestinal contents. Abdominal papillæ absent.

Workers 4·5 mm. long. Head ochroleucous. Antennæ of 14 segments, the 2nd longer than the 3rd. Fenestra absent. Epistoma prominent. Abdomen elongate ovoid, coloured by the intestinal contents.

Nests on the surface of the ground.

Hab. Natal (Estcourt).

Section with Termes nemorosus *for Type.*

Male 5 to 7 mm. long. Ocelli rather large. Fenestra present. Antennæ of 14 or 15 segments, the 2nd longer than the 3rd. Pronotum with straight anterior margin. Wings with the median nerve nearer to the submedian than the subcostal. Abdominal papillæ absent.

Soldier 5 to 8 mm. long. Head as large as the thorax and abdomen together. Antennæ of 14 or 15 segments, the same number as in the imago. Labrum small, white, asymmetrical, obscurely bilobed. Mandibles linear, more than half as long as the head, without piercing-tip or cutting-margin, but characteristically bent: the right slightly S-shaped; the left in the basal third is directed inward, the outer margin becoming superior, the middle third is bent sharply outwards, the apical third is again directed forward, and the upper margin again becomes the outer. Gula long, narrow, narrower at the end of the basal third, broader at the apex. Pronotum short, saddle-shaped, with elevated anterior portion. Abdomen quite white. Abdominal papillæ absent.

Worker 4 to 5 mm. long. Head ochroleucous, often becoming fulvous after death. Antennæ of 14 or 15 segments, the same number as in the imago. Thorax narrow. The abdomen elongate, ovate, coloured by the intestinal contents.

The species of this group often build pillar-like nests, either standing erect or leaning against a tree. They are not at all easy to distinguish one from another; perhaps in some cases it will prove impossible to distinguish them excepting by their nests. (See Plate 22.)

Termes speciosus, n. sp.

Male 7 mm. long, head and portions of the pronotum castaneous, epistoma, mesonotum, and metanotum and underparts isabellinous, dorsal plates of abdomen fulvous. Head ovate. Ocelli large, separated from the eyes by less than half a diameter. Fenestra present. Antennæ of 15 segments, with the 3rd segment slightly larger than the 2nd. Epistoma scarcely prominent. Pronotum with straight anterior margin, converging postero-lateral margins, and obscurely-lobed posterior margin. Anterior wing-stumps larger the posterior. Hind legs reaching to the apex of the abdomen. Abdominal papillæ absent.

Female with the ventral plate of the 7th abdominal segment not half as long as broad, the posterior margin rounded. The abdomen of the queen reaches a length of 40 mm.; there is a considerable quantity of secondary chitinization; the lateral cuticle of the abdomen with faintly pigmented tubercles.

Soldier 8 mm. long. Head 3·2 mm. long, 2 mm. broad, aurantiacous. Antennæ of 14 segments, the 3rd perfectly or imperfectly divided into two; from the 4th to the 10th they are elongate, the four apical segments diminishing in length. The vertical part of the Y-suture deeply coloured. Labrum short, asymmetrical, obscurely lobed. Mandibles linear, much bent: the right is the shorter and the straighter, its lower and outer margin is obtuse, the tip is acute; the left has an obtuse outer and upper margin, and a scissor-like lower and inner margin, the basal third of the mandible is directed inwards, the outer margin becoming gradually the upper, the middle third bends quickly outward, the apical third is directed forward, the outer margin becoming again the upper. Gula long and narrow, broader at the apex. Pronotum short, saddle-shaped, the anterior portion not lobed. Posterior femora reaching to the apex of the abdomen. Abdomen oblong, white. Abdominal papillæ absent.

Worker 5 mm. long. Antennæ of 15 segments. Abdomen large, ovoid, dark from the colour of the intestinal contents.

Hab. Borneo (Sarawak). Type, No. 294.

Termes nemorosus, n. sp. (Pl. 24. figs. 53–56.)

Male 6 mm. long, fuliginous above, mesonotum and metanotum and the underparts umbrinous. Head ovate. Ocelli separated from the eyes by about a diameter. Fenestra obscure.

Antennæ of 14 or 15 segments, the 3rd longer than the 2nd. Epistoma not prominent. Pronotum with anterior margin straight, antero-lateral corners sharp and somewhat deflexed, posterior margin obscurely bilobed. Posterior margins of the mesonotum and metanotum narrow, rather acutely lobed. Anterior wing-stumps a little larger than the posterior. Hind legs scarcely reaching to the end of the abdomen. Abdominal papillæ absent.

Female with the ventral plate of the 7th abdominal segment not half as long as broad, the posterior margin rounded. Abdomen of the queen reaches a length of 22 mm., and is much distended. Lateral cuticle of the abdomen with pigment-spots.

Soldier 5 mm. long. Head ochroleucous, 3 mm. long, 1 mm. broad. Antennæ of 14 segments, the 2nd subequal to the 3rd. Labrum soft, white, $\frac{1}{2}$ mm. long, asymmetrical, slightly lobed, each lobe ending in a soft seta. Mandibles 1·5 mm. long, shaped as in *T. speciosus.* Gula narrowing in the basal third, broadening uniformly in the apical two thirds. Pronotum saddle-shaped, the anterior portion elevated. Hind femora reaching to the apex of the abdomen. Abdominal papillæ absent. Abdomen oblong, white.

Worker 4 mm. long. Head ochroleucous. Antennæ of 14 segments. Thorax narrow. Abdomen elongate ovoid, broader than the head, and dark from intestinal contents.

Hab. Borneo (Sarawak). Type, No. 377.

Section with Termes setiger *for Type.*

Male 4 to 5 mm. long. Antennæ of 14 segments, the 2nd longer than the 3rd, which is short. Fenestra minute. Epistoma convex. Pronotum with straight anterior margin and bilobed posterior margin.

Soldier 3·5 to 5 mm. long. Head oblong. Antennæ of 14 segments, the 2nd subequal to or longer than the 3rd, the 4th shorter, the 8th segment longest, those beyond getting shorter to the apex. Labrum small, white, with two minute acute diverging lobes. Mandibles as long as or longer than the head, slender, slightly downcurved, without tooth or piercing-tip. Gula narrowed in the basal third, gradually broadening beyond it. Pronotum short, saddle-shaped. Hind legs much exceeding the abdomen. Abdomen white. Abdominal papillæ absent.

TERMES SETIGER, n. sp. (Pl. 25. figs. 57–60.)

Male 4·5 mm. long, fuliginous above, the mesonotum, metanotum, and the underparts pale umbrinous. Head ovate. Ocelli separated from the eyes by less than a diameter. Fenestra minute. A pair of pale spots seated near the inner and lower margin of the ocelli. Antennæ of 14 segments, the 2nd longer than the 3rd. Epistoma convex. Pronotum with straight anterior margin and distinctly lobed posterior margin. The posterior margins of the mesonotum and metanotum narrow, with the appearance of a deep median fissure. Anterior wing-stumps a little larger than the posterior.

Female with the ventral plate of the 7th abdominal segment nearly half as long as broad, the posterior margin rounded, in the middle obscurely lobed. The abdomen of the queen reaches a length of 20 mm.; the lateral cuticle of the abdomen is pigment-spotted.

Soldier 5 mm. long. Head 1·5 mm. long, ·8 mm. broad, ochroleucous. Antennæ of 14 segments, the 2nd subequal to the 3rd, the 4th shorter, then lengthening to the 8th, which is nearly twice as long as broad, the others shortening to the apical segment. Labrum small, white, with two minute acute diverging lobes. Mandibles 1·8 mm. long, slender, setiform, at the base directed somewhat upward and inward, then curving somewhat downwards. Gula elongate and narrow, broadening gradually and slightly towards the apex. Pronotum shortly saddle-shaped, with short elevated anterior lobe. Hind legs much exceeding the abdomen. Abdomen white. Abdominal papillæ absent.

Worker 3 mm. long. Head pale. Epistoma convex. Antennæ of 14 segments. Abdomen elongate ovate, the dorsum somewhat arched; coloured by the intestinal contents.

Hab. Borneo (Sarawak), (Marudi). Type, No. 343.

TERMES MINUTUS, n. sp.

Male absent.

Soldier 3·5 mm. long. Head 1 mm. long, 7 mm. broad, ochroleucous. Antennæ of 14 segments, the 2nd longer than the 3rd or 4th, the others increasing to the 8th, which is not quite twice as long as broad. Labrum white, small, with two minute acute diverging lobes. Mandibles 1·2 mm. long, setiform, at the base directed somewhat inward and upward, the left curved slightly

downward. Gula broader towards the apex than at the base. Pronotum short, saddle-shaped, the anterior lobe short, but much elevated. Hind legs much exceeding the abdomen. Abdomen white. Abdominal papillæ absent.

Worker 3 mm. long. Head pale. Antennæ of 14 segments. Epistoma convex. Abdomen oblong, coloured by the intestinal contents.

Hab. Borneo (Sarawak). Type, No. 570.

Section with Termes comis *for Type.*

Male 5 to 7 mm. long. Ocelli almost in contact with the eyes. Antennæ of 15 segments, the 2nd as long as or longer than the 3rd. Fenestra minute. Epistoma convex. Pronotum with straight anterior margin. Anterior wing-stumps a little larger than the posterior. Posterior margins of the mesonotum and metanotum obtusely lobed. Abdominal papillæ absent.

Soldier 4 to 5 mm. long. Head with a broad pointed horn projecting from the front just above the level of the insertion of the antennæ. Antennæ of 14 segments, the 2nd as long or longer than the 3rd or 4th, the 8th segment not longer than those beyond it. Labrum small, white, with two minute acute diverging lobes. Mandibles setiform. Pronotum saddle-shaped. Hind legs not reaching to the end of the abdomen. Abdomen coloured by the intestinal contents. Abdominal papillæ absent.

TERMES ROSTRATUS, n. sp.

Male 4·5 mm. long, latericious above, pale umbrinous below. Head ovate. Ocelli nearly in contact with the eyes. Fenestra narrow. Antennæ of 15 segments, the 3rd very short, the 4th subequal to the 2nd. Epistoma convex. Pronotum semilunar, with nearly straight anterior margin and rounded antero-lateral corners. The posterior margins of mesonotum and metanotum distinctly lobed. The anterior wing-stumps slightly larger than the posterior. Wing 5·5 mm. long; the median nerve runs nearer the submedian than the subcostal, and reaches the apex of the wing; the submedian reaches the apex of the wing and gives about 9 offsets. The chitinous plates are separated by cuticle even in the imago. Abdominal papillæ absent.

Female with the ventral plate of the 7th abdominal segment nearly half as long as broad, the middle of the posterior margin

bilobed. The abdomen of the queen reaches a length of 15 mm.; the lateral cuticle presents faintly pigmented tubercles.

Soldier 4 mm. long. Head 1·1 mm. long, ·7 mm. broad, ochroleucous; there is an anterior horn projecting about ·5 mm. from the head with the lower margin convex. Antennæ of 14 segments, the 2nd longer than the 3rd or 4th, the others lengthening somewhat to the apex. Labrum small, white, curved upwards towards the horn, with two diverging bristles. Mandibles 1 mm. long, setiform, curved considerably downwards. Gula about twice as long as broad, broadening gradually upwards. Pronotum saddle-shaped, the anterior lobe rather large, not much elevated. Hind legs not reaching to the end of the abdomen. Abdomen fusiform, coloured by the intestinal contents. Abdominal papillæ absent.

Worker 3·5 mm. long. Head small, pale. Antennæ of 14 segments. Epistoma prominent. Abdomen coloured by the intestinal contents.

Hab. Borneo (Sarawak); Malay Peninsula (Singapore), (Perak). Type, No. 477.

TERMES COMIS, n. sp. (Pl. **25**. figs. 61–64.)

Male 4 mm. long, isabelline, paler below, the head darker. Head ovate. Ocelli almost in contact with the large eyes. Fenestra minute. Antennæ of 15 segments, the 3rd short, the 2nd subequal to the 4th. Epistoma convex. Pronotum with straight anterior margin, rounded antero-lateral corners, converging postero-lateral margins, and short posterior margin. Posterior margins of the mesonotum and metanotum rather broad, but very slightly lobed. Anterior wing-stumps but little larger than the posterior. Wings 6·5 mm. long, isabellinous; the median is nearer to the submedian than the subcostal, and takes a straight unbranched course to the apex of the wing; the submedian reaches nearly to the apex of the wing and gives 12 to 14 offsets. Abdominal papillæ absent.

Female with the ventral plate of the 7th abdominal segment half as long as broad, the posterior margin convex. Abdomen of the queen reaching to a length of 18 mm.; the lateral cuticle with obscure faintly pigmented tubercles.

Soldier 5 mm. long. Head 1·5 mm. long, ·9 mm. broad, ochroleucous; there is an anterior horn projecting about ·5 mm. from the front of the head; its lower margin is slightly convex.

Antennæ of 14 segments, the 2nd slightly longer than the 3rd or 4th. Labrum small, white, upcurved towards the horn, with two minute, acute, diverging lobes. Mandibles 1·3 mm. long, setiform, at the base directed slightly upwards, then curved somewhat downwards. Gula twice as broad at the apex as the base. Pronotum saddle-shaped, the anterior lobe prominent and saddle-shaped. Hind legs reaching nearly to the apex of the abdomen. Abdomen elongate ovate, coloured by the intestinal contents. Abdominal papillæ absent.

Worker 3·5 mm. long. Head small, pale. Antennæ of 14 segments. Abdomen elongate ovate, black from intestinal contents.

Hab. Borneo (Sarawak); Malay Peninsula (Singapore). Type, No. 305.

The nest of this species is almost always in association with that of *Termes umbrinus*, which it surrounds.

TERMES LATICORNIS.

Soldier 6 mm. long. Head 1·8 mm. long, 1·3 mm. broad, aurantiacous. The anterior horn is short and acute on a broad base. Antennæ of 14 segments, the 2nd longer than the 3rd, the 3rd longer than the 4th, those beyond the 4th subequal. Labrum small, white, with minute, diverging, acute lobes. Mandibles 1·8 mm. long, setiform, at the base directed slightly upwards, then curved somewhat downwards. Gula narrow below, nearly twice as broad towards the apex. Pronotum saddle-shaped. Hind legs reaching nearly to the apex of the abdomen. Abdomen elongate ovate, coloured by the intestinal contents. Abdominal papillæ absent.

Worker 4 mm. long. Head ochroleucous. Antennæ of 14 segments. Epistoma convex. Abdomen rather large, elongate ovate.

Hab. Borneo (Sarawak). Type, No. 231.

TERMES BREVICORNIS, n. sp.

Male 5 mm. long, head castaneous, thorax and abdomen sublatericious above, isabelline beneath. Ocelli almost in contact with the eyes. Fenestra narrow. Antennæ with the 2nd, 3rd, and 4th segments subequal. Epistoma somewhat convex and prominent. Pronotum with the anterior margin slightly concave, the antero-lateral corners obtusely rounded, the posterior margin scarcely lobed. Mesonotum and metanotum with the

posterior margin broadly lobed. Anterior wing-stumps larger than the posterior. Hind legs reaching nearly to the apex of the abdomen. Abdominal papillæ absent.

Female with the ventral plate of the 7th abdominal segment nearly half as long as broad. The abdomen of the queen 15 mm. long, with plates of secondary chitinization, the lateral cuticle with small and scattered pigment-spots.

Soldier 5 mm. long. Head ochroleucous, 1·5 mm. long, 1 mm. broad; the anterior horn very short and obtuse, the head appearing to be subtruncate at the level of the insertion of the antennæ. Antennæ of 14 segments, the 2nd subequal to the 3rd, the 4th shorter, those beyond the 5th subequal in length. Labrum small, pale, slightly upcurved, with two minute, acute, diverging lobes. Mandibles 1·6 mm. long, setiform, at the base directed slightly upwards, then curving downwards. Gula not very narrow at the base, nearly twice as broad towards the apex. Pronotum saddle-shaped, the convex anterior lobe much elevated. Hind legs reaching nearly to the apex of the abdomen. Abdomen elongate ovate, spindle-shaped, coloured by the intestinal contents. Abdominal papillæ absent.

Worker 4 mm. long. Head white, antennæ of 14 segments. Epistoma convex. Abdomen elongate, ovoid, dark from intestinal contents.

Hab. Borneo (Sarawak). Type, No. 458.

Section with Termes foraminifer *for Type.*

Male 5 mm. long. Ocelli approximated to the eyes. Fenestra narrow. Antennæ of 15 segments, the 2nd longer than the 3rd, which is very short. Epistoma convex. Pronotum with straight anterior margin, the posterior margin slightly lobed. Mesonotum and metanotum with the posterior margins obtusely lobed. Abdominal papillæ absent.

Soldier 4 mm. long. Head without horn, but with minute foramen. Antennæ of 13 segments, the 2nd subequal to the 3rd, the 4th longer, those beyond subequal to the 4th. Labrum small, white, with minute, acute, diverging lobes. Mandibles longer than the head, flat, linear, bent, the left more so than the right. Gula uniformly broad. Pronotum short, saddle-shaped. Abdomen coloured by the intestinal contents. Abdominal papillæ absent.

Termes foraminifer. (Pl. 25. figs. 65–68.)

Male 5 mm. long, slender, fuliginous, legs and antennæ paler. Head ovate. Ocelli approximated to the eyes. Fenestra narrow, obscure. Antennæ of 15 segments, the 3rd very short. Epistoma convex. Pronotum with anterior margin nearly straight, posterior margin lobed. Anterior wing-stumps a little larger than the posterior. Wings 6·5 mm. long, hairy; the median runs very close to the submedian, it reaches the apex of the wing, and gives two or three offsets; the submedian gives 6 or 7 offsets. The hind legs do not reach the apex of the abdomen. The abdominal papillæ absent.

Female with the ventral plate of the 7th abdominal segment not half as long as broad. The lateral cuticle of the abdomen has small scattered pigment-spots.

Soldier 4 mm. long. Head 1·2 mm. long, 1 mm. broad, ochroleucous, with a minute median foramen a little above the level of the base of the antennæ. Antennæ of 13 segments, the 2nd and 3rd subequal in length, the 4th longer, those beyond subequal to the 4th. Labrum small, white, with minute acute diverging lobes. Mandibles 1·3 mm. long, flat, linear, bent, the left more so than the right, being arched in the basal half. Gula oblong, uniformly broad. Pronotum saddle-shaped, the anterior lobe short, but much elevated. Hind legs exceeding the abdomen. Abdominal papillæ absent.

Worker 3·5 mm. long. Head pale. Antennæ of 13 segments. Epistoma convex. Abdomen ovoid, dark from intestinal contents.

Hab. Malay Peninsula (Perak); Borneo (Sarawak). Type, No. 114.

Section with Termes atripennis *for Type.*

Male 5 to 10 mm. long. Antennæ of 15 to 17 segments. Epistoma convex and prominent. Anterior wing-stumps a little larger than the posterior. Wings with the median nerve much nearer to the submedian than the subcostal. Abdominal papillæ absent.

Soldier 3 to 5 mm. long. Head subaurantiacous. Rostrum stout. Antennæ of 14 segments, the sixth ovate. Mandibles rudimentary. Gula not so long as broad. Pronotum saddle-shaped, the anterior lobe short, but much elevated. Hind femora reaching to the 7th segment of the abdomen. Abdominal papillæ absent.

TERMES TRINERVIUS, *Rambur*.

Male 10 mm. long, subtestaceous, the head and parts of the dorsal plates of the abdomen castaneous. Head ovate. Ocelli large, separated from the eyes by a diameter. Fenestra narrow. Antennæ of 17 segments, the 3rd slightly longer than the 2nd or 4th. Epistoma prominent and convex. Pronotum 2 mm. broad, large, hairy, the anterior margin straight, somewhat raised, the posterior margin slightly lobed. Mesonotum and metanotum with broad concave posterior border. Anterior wing-stumps slightly larger than the posterior. Wing 20 mm. long; a broad yellow stain runs along the posterior border of the subcostal nerve; the slender median runs near and parallel to the submedian, and bifurcates once or twice in the apical quarter of the wing; the slender submedian gives about 11 offsets and reaches to an eighth from the apex of the wing. Abdominal papillæ absent.

Female with the 7th segment of the abdomen not half as long as broad, the posterior margin convex. Abdomen of queen reaches a length of 15 mm. Secondary chitinization scanty, the lateral cuticle of the abdomen hairy, the pigment-spots minute.

Soldier of two sizes, the larger 4 mm. long. Head 1·5 mm. broad, subaurantiacous. Antennæ of 14 (sometimes 13) segments, the 3rd longer than the 2nd. Rostrum stout. Mandibles rudimentary. Gula scarcely half as long as broad. Pronotum saddle-shaped, the anterior portion much elevated, very short. Posterior femora reaching to the 7th segment of the abdomen. Abdomen large ovoid, the dorsum arched. The smaller soldiers 3 mm. long. Head ·8 mm. broad.

Worker 5 mm. long. Head more or less castaneous. Antennæ of 15 segments. Epistoma very convex and prominent. Abdomen large ovoid. Hind legs exceeding the abdomen.

Nests forming rounded mounds on the surface of the ground; the cells beneath the outer shell are stuffed with bits of grass.

Hab. Africa.

TERMES CONSTRICTUS, n. sp.

Male 5 mm. long; head and thorax latericious, abdomen castaneous, legs ochroleucous. Head ovate. Ocelli large, separated from the eyes by a diameter. Fenestra diffuse. Antennæ of 15 segments. Epistoma scarcely prominent. Pronotum 1·2 mm.

broad, subsemilunar, the anterior margin slightly concave, the antero-lateral corners rounded. Mesonotum and metanotum with the posterior margins broad, concave. Hind legs much exceeding the abdomen. Abdominal papillæ absent.

Female with the ventral plate of the 7th segment half as long as broad. In the queen the abdomen reaches a length of 19 mm. Secondary chitinization extensive: lateral cuticle with numerous pigment-spots and hairs.

Soldier 4 mm. long. Head ·8 mm. broad, fulvous. Antennæ of 14 segments, the 3rd shorter than the 2nd, the 6th ovate. Rostrum shorter than the head. Mandibles rudimentary. Gula nearly as long as broad. Anterior elevated portion of pronotum very short. Posterior femora reaching to the 7th segment of the abdomen. Abdomen ovoid, the dorsum somewhat arched. Abdominal papillæ absent.

Worker 4·5 mm. long. Head subcastaneous. Antennæ of 15 segments. Hind legs exceeding the abdomen. Abdomen ovoid.

Nest terrestrial.

Hab. Borneo (Sarawak). Type, No. 292.

TERMES FUSCIPENNIS, n. sp. (Pl. 25. figs. 69–72.)

Male 8 mm. long, castaneous, abdomen beneath umbrinous, legs subisabelline. Head ovate. Ocelli not large, separated from the eyes by twice their diameter. Fenestra minute. Antennæ of 15 segments, the 3rd somewhat longer than the 2nd. Epistoma slightly prominent and convex. Pronotum 1·5 mm. broad, subtriangular, the angles rounded. Mesonotum and metanotum with posterior margins broad, slightly concave. Wing 13·5 mm. long, fuliginous; the subcostal very broad and with a yellow stain along its posterior border; the median nerve runs near and parallel to the submedian, it reaches the apex of the wing and gives 4 offsets in the apical third; the submedian reaches to a quarter from the apex of the wing and has 10 offsets. Hind legs reach to the apex of the abdomen. Abdominal papillæ absent.

Female with the ventral plate of the 7th abdominal segment fully half as long as broad, subtriangular, with the lateral angles rounded. The abdomen of the queen reaches a length of 16 mm. or more; the lateral cuticle with numerous minute pigment-spots and hairs.

Soldier 4·5 mm. long, slender. Head 1·2 mm. broad, red-testaceous. Antennæ with the 3rd segment longer than the 2nd, the 6th ovate. Rostrum conical. Mandibles rudimentary. Gula half as long as broad. Pronotum saddle-shaped, the elevated anterior portion very short. Posterior femora reaching to the 7th abdominal segment. Abdomen oblong, the dorsal surface somewhat arched. Abdominal papillæ absent.

Worker 4·5 mm. long. Head testaceous. Antennæ of 15 segments. Hind legs reaching nearly to the apex of the abdomen. Abdomen ovoid, the dorsum arched.

The spirit in which these specimens were first placed became coloured red. The nest was on the trunk of a live tree.

Hab. Borneo (Sarawak). Type, No. 446.

Termes atripennis, n. sp.

Male 9 mm. long, fuliginous, mesonotum, metanotum, and the parts below umbrinous. Head ovate. Ocelli separated from the eyes by a diameter. Fenestra as large and distinct as an ocellus. Antennæ of 15 segments, the 3rd but little larger than the 2nd. Epistoma but slightly convex and prominent. Pronotum 1·5 mm. broad, subtriangular, the angles rounded. Mesonotum and metanotum with the posterior margins broad and markedly concave. Wings 22 mm. long, fuliginous; the subcostal nerve broad; the median runs near and parallel to the submedian, it is slender, reaches the apex of the wing, and gives several branches in the apical half; the submedian gives 8 offsets and reaches to a third from the apex of the wing.

Female with the ventral plate of the 7th segment half as long as broad. The abdomen of the queen reaches to a length of 18 mm.; secondary chitinization is well marked; the lateral cuticle of the abdomen has numerous small pigment-spots and hairs.

Soldier 5·5 mm. long. Head 1·5 mm. broad, fulvous. Antennæ of 14 segments, the 2nd and 3rd subequal, much smaller than the 4th, the 6th ovate. Rostrum large, conical. Mandibles rudimentary. Gula not so long as broad. Pronotum saddle-shaped, the anterior elevated portion very short. Pronotum, mesonotum, and metanotum fulvous, the dorsal plates of the abdomen fuliginous, arched. Posterior femora reach to the 7th segment of the abdomen. Abdominal papillæ absent.

Worker 6 mm. long. Head subcastaneous, the dorsal plates of the abdomen fuliginous. Antennæ of 15 segments. λ-suture well marked. Epistoma scarcely prominent. Abdomen large, with the dorsum much arched.

Hab. Borneo (Sarawak). Type, No. 427.

TERMES OVIPENNIS, n. sp.

Male 7 mm. long, above castaneous, the mesonotum and metanotum testaceous, below umbrinous. Head ovate. Ocelli large, distant, 1 diameter from the eyes. Fenestra small, round. Antennæ of 15 segments, the 2nd and 3rd subequal. Epistoma scarcely prominent. Pronotum 1·2 mm. broad; the anterior margin slightly concave, antero-lateral angles rounded, depressed, postero-lateral margins straight, converging; the posterior margin lobed. Mesonotum and metanotum with the posterior margins lobed, the lobes obtusely pointed. Wings 11·5 mm. long, fuliginous; the subcostal nerve rather broad and with a yellow stain along its posterior border; the median runs much nearer the submedian than the subcostal, it reaches the apex of the wing, near to which it gives an offset; the submedian reaches to about a tenth of the apex of the wing and gives about 10 offsets. The hind legs reach to the apex of the abdomen. Abdominal papillæ absent.

Female with the ventral plate of the 7th segment of the abdomen not half as long as broad, the posterior margin concave towards the sides, convex in the middle.

Soldier 4 mm. long. Head 1 mm. broad, ochraceous. Antennæ of 14 segments, the 3rd a little longer than the 2nd. Rostrum somewhat slender. Mandible rudimentary. Gula as long as broad. Pronotum saddle-shaped, very short. Posterior femora reaching to the 7th abdominal segment. Abdomen elongate ovate, the plates but little chitinized. Abdominal papillæ absent.

Worker 4 mm. long. Head ochroleucous. Antennæ of 14 segments.

Hab. Borneo (Sarawak). Type, No. 348.

Section with Termes regularis *for Type.*

Male with antennæ of 14 segments.

Soldier 3 to 4 mm. long. Head 1 mm. broad or less, ochraceous. Antennæ of 12 or 13 segments. Rostrum slender. Mandible

rudimentary. Gula as long as broad. Pronotum saddle-shaped, the anterior lobe much elevated, but very short. Abdominal papillæ absent.

Termes regularis, n. sp. (Pl. 25. figs. 73–75.)

Male 6·5 mm. long, dark castaneous above, umbrinous beneath. Head ovate, hairy. Ocelli distant one diameter from the eye. Fenestra very minute. Antennæ of 14 segments, the 3rd very short. Epistoma scarcely convex. Pronotum 1·2 mm. broad, subsemilunar, the antero-lateral angles rounded, slightly depressed. Mesonotum and metanotum with the posterior margins slightly notched. Wings 8·5 mm. long, fuliginous; the subcostal nerve broad; the median fine, running nearer to the submedian than the subcostal, reaches the apex of the wing and gives two or three branches; the submedian reaches to about a tenth from the apex of the wing and has about 10 offsets. Hind legs not reaching to the apex of the abdomen. Abdominal papillæ absent.

Female with the ventral plate of the 7th abdominal segment half as long as broad, the posterior margin uniformly rounded.

Soldier 4 mm. long. Head 1 mm. broad, ochraceous. Antennæ of 13 segments, the 2nd longer than the 3rd, the 3rd longer than the 4th. Rostrum slender. Mandibles rudimentary. Gula as long as broad. Pronotum saddle-shaped, the anterior portion short, but much elevated. Hind legs exceeding the abdomen. Abdomen elongate, ovoid. Abdominal papillæ absent.

Worker 6 mm. long. Head ochroleucous. Antennæ of 13 segments. Abdomen large, ovoid.

Hab. Borneo (Sarawak). Type, No. 279.

Termes inanis, n. sp.

Nymph with antennæ of 14 or 15 segments.

Soldier 3·5 mm. long. Head 8 mm. broad, ochroleucous. Antennæ of 12 segments, the 2nd longer than the 3rd. Rostrum slender, nearly as long as the head. Mandibles rudimentary. Gula nearly as long as broad. Pronotum saddle-shaped, the anterior lobe short, much elevated. Abdomen ovoid, the dorsum much arched, especially at the base.

Worker 4 mm. long. Head ochroleucous. Antennæ of 13 segments. Abdomen ovoid, the dorsum much arched.

Hab. Malay Peninsula (Perak). Type, No. 121.

Termes aciculatus.

Nymph with 14 segments to the antennæ.

Soldier 3·5 mm. long, slender. Head 8 mm. broad, ochroleucous. Antennæ of 12 segments, the 3rd shorter than the 2nd. Rostrum slender, much shorter than the head. Mandibles rudimentary. Gula nearly as long as broad. Pronotum saddle-shaped, the anterior lobe elevated, but very short. Hind legs not reaching the apex of the abdomen. Abdomen oblong. Abdominal papillæ absent.

Worker 4 mm. long, slender. Head ochroleucous. Antennæ of 14 segments. Abdomen oblong.

Hab. Borneo (Sarawak). Type, No. 447.

Section with Termes singaporiensis *for Type.*

Male 6 to 8 mm. long Eyes and ocelli large, approximated. Fenestra present. Antennæ of 15 segments, the 3rd slightly longer than the 2nd. The wings umbrinous; the median nerve near and parallel to the submedian. Abdominal papillæ absent.

Soldier 3 mm. long. Head fulvous. Antennæ of 12 to 13 segments, the 3rd longer than the 2nd or 4th, the 6th ovate. Rostrum short, conical. Mandibles rudimentary. Gula not so long as broad. Pronotum saddle-shaped, the anterior lobe short, but elevated. Hind legs reaching to the 7th abdominal segment. Abdominal papillæ absent.

Most of the species of this section build spherical nests raised on bushes a few feet from the ground. The exterior of the nest is a paper-like cover resembling bark in external appearance, but very fragile. Inside this comes the nest proper; it has a hard outer shell full of intercommunicating cells, and a soft centre portion of weak material. The king and queen are found in the hard outer portion, the young larvæ in the soft inner portion.

Termes borneensis, n. sp.

Male 7 mm. long, fuliginous, head castaneous, the anterior portions of the mesonotum and metanotum, the antennæ, and the legs ochroleucous. Head ovate. Ocelli separated from the eyes by nearly a diameter. Fenestra rather obscure. Antennæ of 15 segments, the 3rd subequal to the 2nd. Epistoma not prominent. Pronotum 1 mm. broad, the anterior margin straight. The posterior margins of the mesonotum and meta-

notum with two broad obtusely angled lobes. Anterior wing-stumps but slightly larger than the posterior. Wings 9 mm. long by 2·5 mm. broad, fuliginous; the median runs nearer the submedian than the subcostal and gives two or three offsets in the apical quarter of the wing; the submedian reaches to a fifth from the apex of the wing and has 8 offsets. The hind legs reach to the apex of the abdomen.

Soldier 3 mm. long, slender. Head ·5 mm. broad, fulvous. Antennæ of 13 segments, the 3rd longer than the 2nd, the 2nd longer than the 4th. Rostrum conical; viewed from in front there is a marked swelling at the junction of the rostrum and the head. Mandibles rudimentary. Gula scarcely as long as broad. Pronotum very short. Posterior femora reaching to the 6th segment of the abdomen. Abdomen elongate ovate. Abdominal papillæ absent.

Worker 3 mm. long. Head subcastaneous. Antennæ of 14 segments. Abdomen ovate, the dorsum arched.

Hab. Borneo (Sarawak). Type, No. 272.

TERMES MATANGENSIS, n. sp.

Male 8 mm. long; head subcastaneous, abdomen fulvous, thorax, legs, and antennæ ochraceous. Head ovate. Eyes and ocelli very large, approximated. Fenestra obscure. Antennæ of 15 segments, the 3rd but little longer than the 2nd. Epistoma scarcely prominent. Pronotum 1·6 mm. broad, subreniform, the antero-lateral corners depressed, the posterior margin bilobed. Mesonotum and metanotum with the posterior margins broad and slightly concave. The anterior wing-stumps but little larger than the posterior. Wings 14 mm. long, 3·5 mm. broad, isabelline; subcostal broad; the slender median runs near the submedian and parallel to it, and reaches the apex of the wing, being either branched or unbranched, occasionally there are several anterior offsets; the slender submedian reaches nearly to the apex of the wing and has 13 offsets. The hind legs reach to the apex of the abdomen. The abdominal papillæ are absent.

Female with the ventral plate of the 7th abdominal segment not half as long as broad. The abdomen of the queen reaches a length of 18 mm.; there is some secondary chitinization; the lateral cuticle of the abdomen has numerous minute pigment-spots and hairs.

Soldier 4·5 mm. long. Head 1·5 mm. broad, fulvous. Antennæ of 13 segments, the 3rd longer than the 2nd, the 2nd longer than the 4th, the 6th ovate. Rostrum stout, conical. Mandibles rudimentary. Gula nearly as long as broad. Pronotum saddle-shaped, short; the anterior lobe short, much elevated. Posterior femora reaching to the 7th abdominal segment. Abdomen ovoid, the dorsum arched. Abdominal papillæ absent.

Worker 5·5 mm. long. Head castaneous. Antennæ of 14 segments. Abdomen large, ovoid, the dorsum arched.

Hab. Borneo (Sarawak). Types, Nos. 358, 359, 360.

TERMES LATIFRONS, n. sp.

Male 6 mm. long. Thorax and abdomen subumbrinous above, beneath paler. Head ovate. Ocelli large, approximated to the eyes. Fenestra small. Antennæ of 15 segments, the 3rd shorter than either 2nd or 4th. Pronotum 1·2 mm. broad, the anterior margin nearly straight, the antero-lateral angles depressed, the postero-lateral margins straight, converging. Mesonotum with the posterior margin broad, slightly concave. Metanotum with posterior margin rather short. Anterior wing-stumps but little larger than the posterior. Wings 10·5 mm. long, umbrinous, the costal nerve and a broad stain behind it ochroleucous; the median nerve runs nearer the submedian than the subcostal, and reaches the apex of the wing, shortly before which it may bifurcate; the submedian reaches to a tenth from the apex of the wing and has 9 offsets. Hind legs slightly exceeding the abdomen. Abdominal papillæ absent.

Soldier 3 mm. long. Head 1 mm. broad, fuscous. Antennæ of 13 (sometimes 12) segments. Rostrum stout, conical, its anterior surface in a plane with the front surface of the head. Mandibles rudimentary. Gula not so long as broad. Pronotum short, saddle-shaped; the anterior lobe short, somewhat elevated. Posterior femora reaching to the 8th abdominal segment. Abdomen ovoid, the dorsum arched. Abdominal papillæ absent.

Worker 4 mm. long. Head castaneous. Antennæ of 14 segments. Hind legs exceeding the abdomen. Abdomen ovoid, the dorsum arched.

Nest on the trunks of trees.

Hab. Borneo (Sarawak). Type, No. 127.

This species does not build spherical nests. The soldiers are at once distinguished from those of the following species by the stoutness of the conical rostrum.

TERMES SARAWAKENSIS, n. sp.

Male 7 mm. long. Head dark castaneous; legs and thorax subisabelline; abdomen fuliginous above, umbrinous below. Head ovate. Eyes and ocelli large, approximated. Fenestra large, elongate. Antennæ of 15 segments. Epistoma slightly prominent. Pronotum with the anterior margin straight, in the middle elevated, the antero-lateral corners depressed, the postero-lateral margins slightly convex, converging. Mesonotum with the posterior margin broad, concave. Metanotum with the posterior margin narrower. Anterior wing-stumps markedly larger than the posterior. Wings 12 mm. long, umbrinous, a yellow stain running behind the subcostal nerve; the median nerve runs nearer the submedian than the subcostal, it becomes fainter towards the apex, and disappears before reaching the apex of the wing; the submedian has 9 offsets, it reaches to a tenth from the apex of the wing, but becomes very faint towards its apex. Hind legs reaching to the 8th abdominal segment. Abdominal papillæ absent.

Female with the ventral plate of the 7th abdominal segment not half as long as broad, the postero-lateral margins nearly straight. The abdomen of the queen reaches a length of 18 mm.; there are distinct plates of secondary chitinization; the lateral cuticle presents minute pigment-spots and hairs.

Soldier 3 mm. long. Head ·8 mm. broad, fulvous. Antennæ of 13 segments, the 3rd much longer than the 2nd or 4th. Rostrum conical, somewhat stout, its anterior surface not quite in a plane with the anterior surface of the head. Mandibles rudimentary. Gula not so long as broad. Pronotum saddle-shaped, the anterior lobe short, elevated. Posterior femora reach to the 8th segment of the abdomen. Abdomen ovoid, the dorsal plates arched, fuliginous. Abdominal papillæ absent.

Worker 4 mm. long. Head castaneous. Antennæ of 14 segments. Abdomen large, ovoid, the dorsal surface arched.

Nests spherical, built on the stems of shrubs and placed a few feet from the surface of the ground.

Borneo (Sarawak). Type, No. 265.

TERMES SINGAPORIENSIS, n. sp. (Pl. 25. figs. 76–79.)

Male 7 mm. long. Head castaneous; thorax and legs isabelline; abdomen fuliginous above, umbrinous below. Head ovate. Eyes and ocelli large, approximated. Fenestra elongate.

Epistoma slightly convex. Pronotum with the anterior margin nearly straight, the antero-lateral angles scarcely deflexed, the postero-lateral margins nearly straight. Mesonotum with the posterior margin rather broad and concave. Metanotum with the posterior margin narrower. The anterior wing-stumps considerably larger than the posterior. Wings 12 mm. long, umbrinous; there is a yellow stain along the posterior border of the subcostal; the median runs nearer the submedian than the subcostal, it becomes very faint but reaches the apex of the wing, it may bifurcate in the apical quarter of the wing; the submedian gives 8 offsets, it becomes very fine but reaches to a ninth from the apex of the wing. The hind legs exceed the abdomen. The abdominal papillæ are absent.

Female with the ventral plate of the 7th abdominal segment not half as long as broad, the postero-lateral margins rounded. The abdomen with plates of secondary chitinization, with hairs and faint pigment-spots.

Soldier 3 mm. long. Head ·7 mm. broad, fulvous. Antennæ of 12 segments, the 3rd longer than the 2nd, shorter than the 4th (seldom of 13 segments, the 4th shorter than the 3rd). Rostrum conical, the anterior surface nearly in a plane with the anterior surface of the head; there is at the junction of head and rostrum a distinct swelling best seen from in front. Mandibles rudimentary. Gula not so long as broad. Pronotum saddle-shaped, the anterior lobe short, elevated. Posterior femora reach to the 7th segment of the abdomen. Abdomen ovoid, the dorsal plates arched, umbrinous. Abdominal papillæ absent.

Worker 4 mm. long. Head castaneous. Antennæ of 14 segments. Abdomen ovoid, the dorsum arched.

Nests spherical, placed on the stems of shrubs a foot or two from the ground.

Hab. Malay Peninsula (Singapore). Type, No. 98.

Very close to *T. sarawakensis*, but the soldiers are smaller, with antennæ of 12 segments and rostrum slightly swollen at the base.

TERMES GERMANUS, n. sp.

Male 7 mm. long. Head castaneous; legs and thorax sub-isabellinous; abdomen fuliginous. Head ovate. Eyes and ocelli large, approximated. Fenestra narrow, elongate. Antennæ of 15 segments. Epistoma slightly prominent. Pronotum with nearly straight anterior margin; antero-lateral angles but

slightly deflexed; postero-lateral margins nearly straight. Posterior margin of the mesonotum somewhat broad, concave; posterior margin of the metanotum narrower. Wings 11 mm. long, umbrinous; the median is nearer to the submedian than the subcostal, it reaches to the apex of the wing, it may or may not have offsets; the submedian has 8 offsets and reaches nearly to the apex of the wing. The hind legs exceed the abdomen. The abdominal papillæ absent.

Female with the ventral plate of the 7th abdominal segment not half as long as broad. The abdomen of the queen reaches a length of 16 mm.; there is well-marked secondary chitinization; the cuticle has numerous minute pigment-spots and hairs.

Soldier 3 mm. long. Head ·8 mm. broad, dark castaneous. Antennæ of 13 segments, the 3rd longer than the 2nd or 4th. Rostrum stout, conical, with red tip, its anterior surface is not in a plane with the anterior surface of the head. Mandibles rudimentary. Gula not so long as broad. Pronotum saddle-shaped, the anterior lobe short, elevated. Posterior femora umbrinous, reaching to the 7th abdominal segment. Abdomen ovoid, the dorsal plates arched, fuliginous. Abdominal papillæ absent.

Worker 4 mm. long. Head castaneous. Antennæ of 14 segments. Abdomen ovoid, with the dorsum arched.

Nest spherical.

Hab. Malay Peninsula (Singapore, Bukit Timah). Type, No. 20.

Only one nest of this was found; it was 10 feet from the ground and larger than nests of *T. singaporiensis.* It is quite possible that this species and the last two should be regarded as varieties of a single species.

Section with Termes lacessitus *for Type.*

Males 8 to 9 mm. long. Eyes and ocelli large. Fenestra present. Antennæ of 15 segments, the 3rd slightly longer than the 2nd. Wings fuliginous, the median nearer the submedian than the subcostal. Abdominal papillæ absent.

Soldier 4 mm. long. Head 1 mm. broad or less. Antennæ of 14 segments, the 3rd longer than the 2nd, shorter than the 4th, the 7th elongate, at least twice as long as broad. Rostrum rather slender, its anterior margin forming a curve with the front surface of the head. Mandibles rudimentary. Gula not so long as broad. Pronotum saddle-shaped, the anterior lobe

short, not much raised. Abdomen small, oblong. Posterior femora exceeding the abdomen. Abdominal papillæ absent.

All the species of this group build rounded nests on the boughs of bushes. Their nests are very fragile. The king and queen live just beneath the main supporting bough. The queen has the abdomen remarkably arched; when alive her abdomen has generally a bright orange colour, but the colour soon disappears in spirit. The soldiers are very eager to attack when the nest is opened, but the workers rush out and throw themselves headlong to the ground.

TERMES LABORATOR, n. sp.

King 8 mm. long. Head castaneous; thorax latericious; abdomen badious; legs ochraceous. Head ovate. Ocelli separated from the eyes by more than a diameter. Fenestra as large as an ocellus. Antennæ with the 3rd segment longer than the 2nd. Epistoma slightly prominent. Pronotum half as long as broad, the anterior margin nearly straight, the antero-lateral angles rounded, slightly depressed. Mesonotum and metanotum with the posterior margins broad, obtusely lobed. Anterior wing-stumps larger than the posterior. Abdominal papillæ absent.

Female with the ventral plate of the 7th abdominal segment not half as long as broad, the postero-lateral margins slightly concave; the abdomen of the queen reaches a length of 12 mm., the dorsum is much arched; there is marked secondary chitinization; the lateral cuticle of the abdomen has minute pigment-spots and hairs.

Soldier 4 mm. long. Head badious; thorax and abdomen umbrinous; legs isabelline. Head 1 mm. broad. Antennæ 2·5 mm. long; of 14 segments, the 3rd much longer than the 2nd, but shorter than the 4th; the 7th is the longest, it is more than twice as long as broad. The rostrum is rather slender, its anterior surface makes a marked curve with the anterior surface of the head. Viewed from in front there is a swelling between the base of the rostrum and the base of the antennæ. Rudimentary mandibles visible. Gula not so long as broad. Pronotum obscurely saddle-shaped, the anterior lobe short, not much elevated. Posterior femora reaching nearly to the apex of the abdomen. Abdomen ovoid, somewhat laterally compressed, the dorsal plates arched. Abdominal papillæ absent.

Worker 5 mm. long. Head castaneous; thorax and abdomen umbrinous. Antennæ of 15 segments. Abdomen large, ovoid, with arched dorsum. Hind legs exceeding the abdomen.

Nests spherical, about 10 feet from the ground.

Hab. Malay Peninsula (Malacca). Type, No. 535.

TERMES LACESSITUS, n. sp. (Pl. 25. figs. 80–82.)

Imago castaneous above; head dark castaneous; antennæ, legs, and abdomen below fulvous. Head ovate. Ocelli separated from the eyes by a diameter. Fenestra narrow, obscure. Antennæ of 15 segments, the 3rd longer than the 2nd. Epistoma scarcely prominent. Pronotum half as long as broad, the anterior margin nearly straight, slightly elevated; the antero-lateral angles rounded, somewhat deflexed; the postero-lateral angles nearly straight. The posterior margins of the mesonotum and metanotum rather broad, slightly concave. Anterior wing-stumps larger than the posterior. The abdomen of the queen reaches a length of 12 mm.; the dorsum is much arched, especially near the base; secondary chitinization scanty, the lateral cuticle of the abdomen with minute pigment-spots and hairs.

Soldier 4 mm. long. Head black; thorax and abdomen fuliginous; the tarsi pale. In many of the soldiers (perhaps young ones) the abdomen is isabelline. Head ·8 mm. broad. Antennæ 3 mm. long; of 14 segments, the 3rd twice as long as the 2nd, then increasing to the 8th, which is three times as long as broad. Rostrum large, its anterior surface making a distinct curve with the anterior surface of the head. Rudimentary mandibles easily visible. Gula not half as long as broad. Pronotum saddle-shaped, the anterior lobe short and but little raised. Posterior femora exceeding the abdomen. Abdominal papillæ absent.

Worker 5 mm. long. Head castaneous; thorax and abdomen umbrinous. Antennæ of 15 segments. Hind legs exceeding the abdomen. Abdomen large, ovoid, the dorsum arched.

Nests spherical; on the branches of shrubs 10 feet from the ground.

Hab. Malay Peninsula (Singapore). Type, No. 102.

TERMES FILICORNIS, n. sp.

Male 8 mm. long; fuliginous, head castaneous, legs ochraceous. Head ovate. Ocelli separated from the eyes by two

diameters. Fenestra not as large as an ocellus. Antennæ of 15 segments, the 3rd somewhat larger than the 2nd. Epistoma convex and prominent. Pronotum about half as long as broad, the anterior margin nearly straight; the antero-lateral angles rounded, scarcely deflexed; the postero-lateral margins nearly straight. Mesonotum and metanotum with the posterior margins broad, obtusely lobed. Anterior wing-stumps larger than the posterior. Wings 12 mm. long, umbrinous, a faint yellow stain runs along the posterior border of the subcostal; the median nerve is nearer the submedian than the subcostal, it bifurcates and becomes faint in the apical third of the wing; the submedian has 10 offsets, it becomes faint towards the apex, but reaches the posterior margin a fifth from the apex of the wing. The hind legs reach to the 7th abdominal segment. Abdominal papillæ absent.

Female with the ventral plate of the 7th abdominal segment not half as long as broad, the postero-lateral margins somewhat concave.

Soldier 3·5 mm. long. Head subcastaneous; thorax and abdomen umbrinous; antennæ isabelline; legs ochroleucous. Antennæ 3 mm. long, the 3rd segment not much longer than the 2nd, the 4th much longer, the 7th the longest, three times as long as broad. Rostrum moderate, its anterior surface making a marked curve with the anterior surface of the head. Rudimentary mandibles easily visible. Gula shorter than long. Pronotum saddle-shaped, the anterior lobe very short, scarcely elevated. Posterior femora exceeding the abdomen. Abdomen small, ovoid. Abdominal papillæ absent.

Worker 4 mm. long. Head subcastaneous; thorax and abdomen umbrinous above. Antennæ of 15 segments. Hind legs exceeding the abdomen. Abdomen large, ovoid, the dorsal plates arched.

Hab. Borneo (Sarawak). Type, No. 312.

TERMES SORDIDUS, n. sp.

Male 7·5 mm. long; fuliginous, head castaneous, legs and antennæ umbrinous. Ocelli separated from the eyes by half a diameter or less. Fenestra rather small. Antennæ of 15 segments, the 3rd rather larger than the 2nd. Epistoma slightly convex and prominent. Pronotum more than half as long as broad; the anterior margin straight, slightly elevated; the

antero-lateral angles rather sharply rounded, slightly depressed; the postero-lateral margins nearly straight. Mesonotum and metanotum with posterior margins broad, very slightly concave. Anterior wing-stumps larger than the posterior. Wings 12 mm. long, umbrinous; the median nerve not much nearer to the submedian than the subcostal, it gives one or two offsets and reaches the apex of the wing, but becomes there very faint; the submedian has 6 offsets, it reaches the posterior margin at a third from the apex of the wing. Hind legs reaching to 7th abdominal segment. Abdominal papillæ absent.

Female with the ventral plate of the 7th abdominal segment not half as long as broad, the postero-lateral margins concave. The abdomen of the queen reaches a length of 14 mm., the dorsum is much arched, especially at the base; secondary chitinization is absent; the lateral cuticle of the abdomen has minute pigment-spots and hairs.

Soldier 3·5 mm. long, fuliginous; head black. Antennæ 3 mm. long, of 14 segments, the 3rd longer than the 2nd, but very variable in length, the 7th the longest, scarcely 3 times as long as broad. Rostrum rather large. Rudimentary mandibles easily visible. Gula nearly as long as broad. Pronotum saddle-shaped, the anterior lobe very short, scarcely elevated. Posterior femora exceeding the abdomen. Abdomen small, ovoid. Abdominal papillæ absent.

Worker 5 mm. long, umbrinous, the head castaneous. Antennæ of 15 segments. Hind legs exceeding the abdomen. Abdomen large, ovoid.

Hab. Borneo (Sarawak). Type, No. 261.

Termes albipes, n. sp.

Male 8·5 mm. long; dark castaneous, legs fuliginous, the tarsi and apical segments of the antennæ pale. Head ovate. Ocelli distant half a diameter from the eyes. Fenestra very narrow, almost absent. Antennæ of 15 segments, the 3rd slightly larger than the 2nd. Epistoma very slightly convex. Pronotum half as long as broad; anterior margin straight; antero-lateral corners obtusely rounded; postero-lateral margins nearly straight. Mesonotum and metanotum with the posterior margin broad and markedly concave. Anterior wing-stumps somewhat larger than the posterior. Wings 14 mm. long, umbrinous; the median much nearer the submedian than the

subcostal, becomes very fine, but gives two or three offsets and reaches the apex of the wing; the submedian has 9 offsets and reaches to a fifth from the apex of the wing. The hind legs reach to the apex of the abdomen. Abdominal papillæ absent.

Female with the ventral plate of the 7th abdominal segment half as long as broad, its postero-lateral margins concave. Abdomen of the queen reaches a length of 14 mm., the dorsum is much arched; secondary chitinization is scanty; the lateral cuticle has minute pigment-spots and hairs.

Soldier 4 mm. long; black above, fuliginous below, the 12 apical segments of the antennæ, the tibiæ, and the tarsi white. Head ·8 mm. broad. Antennæ of 14 segments, the 3rd longer than the 2nd, the 7th the longest, quite three times as long as broad. Rostrum rather large, its anterior surface making a marked curve with the anterior surface of the head. Rudimentary mandibles easily visible. Gula nearly as long as broad. Pronotum saddle-shaped, the anterior lobe short and little elevated. Posterior femora exceeding the abdomen. Abdomen small, ovoid. Abdominal papillæ absent.

Worker 5 mm. long, fuliginous; head subcastaneous. Antennæ of 15 segments. Abdomen rather large, ovoid, the ventral plates much arched.

Hab. Borneo (Sarawak). Type, No. 363.

Section with Termes hospitalis *for Type.*

Male 8 to 18 mm. long. Ocelli large, but separated from the eyes by a diameter. Fenestra large. Antennæ of 15 segments, the 3rd twice as long as the 2nd. Wings fuliginous, the median near and parallel to the submedian.

Soldier 4 mm. long. Head black. Antennæ of 14 segments, the 3rd twice as long as the 2nd and generally longer than the 4th, the 6th elongate, at least twice as long as broad. Rostrum slender, its anterior border forming a curve with the front of the head, its tip red. Mandibles rudimentary. Gula not so long as broad. Pronotum saddle-shaped but well chitinized, the anterior lobe but little elevated. Abdomen ovoid, not large. Legs very long, the posterior femora exceeding the abdomen. Abdominal papillæ absent.

The nests of this group are generally in the ground, but they may be on large tree-trunks. The termites traverse the jungle in long troops, which may be met returning any hour till mid-day, the workers carrying each a ball of food in its mouth.

Termes umbrinus, n. sp.

Male 10 mm. long; above castaneous, beneath fuliginous, tibiæ pale. Head ovate. Ocelli distant one diameter from the eyes. Fenestra white, larger than an ocellus. Antennæ of 15 segments, the 3rd longer than the 2nd or 4th. Epistoma but slightly convex. Pronotum more than half as long as broad, the anterior margin straight, the antero-lateral corners depressed, obtusely rounded, the postero-lateral margins nearly straight, the posterior margin broadly rounded. Mesonotum and metanotum with posterior margins broad, concave. Anterior wing-stumps slightly larger than the posterior. Wing 14 mm. long, umbrinous; subcostal nerve thick; the median nerve runs much nearer the submedian than the subcostal, it has 4 or 5 offsets and reaches the apex of the wing but becomes very faint; the submedian has 10 offsets and reaches to a third from the apex of the wing. Hind legs much exceeding the abdomen. Abdominal papillæ absent.

Female with the ventral plate of the 7th abdominal segment not half so long as broad, the postero-lateral margins slightly concave. The abdomen of the queen reaches a length of 22 mm.; secondary chitinization strongly developed; the lateral cuticle of the abdomen presents numerous minute pigment-spots and hairs.

Soldier 4 mm. long; umbrinous. Head 1 mm. broad. Antennæ 4 mm. long, of 14 segments, the 3rd the longest, about 3 times as long as the 2nd. Rostrum slender, the anterior surface making a curve with the anterior surface of the head. Rudimentary mandibles easily visible. Gula not so long as broad. Pronotum saddle-shaped, the anterior lobe but little raised. Posterior femora exceeding the abdomen in length. Abdomen ovoid. Abdominal papillæ absent.

Worker 4 mm. long; umbrinous, head castaneous. Antennæ of 15 segments. Posterior femora reaching to the 8th segment of the abdomen. Abdomen large, ovoid, laterally compressed, the dorsal plates much arched.

Hab. Borneo (Sarawak). Type, No. 258.

Termes hospitalis, n. sp. (Pl. 25. figs. 83–86.)

Male 9 mm. long; castaneous, the ventral plates of the abdomen umbrinous except at the sides, the tibiæ and antennæ umbrinous. Head ovate. Ocelli separated from the eyes by less than a diameter. Fenestra smaller than an ocellus. Antennæ of 15 segments, the 3rd longer than the 2nd or 4th. Epistoma

slightly convex and prominent. Pronotum more than half as long as broad, the anterior margin straight, the antero-lateral angles depressed, rounded; the postero-lateral margins straight. Mesonotum and metanotum with the posterior margins broad, slightly concave. Anterior wing-stumps slightly larger than the posterior. Wings 14 mm. long, umbrinous; the subcostal is broad and fuliginous, and has a yellow stain along its posterior border; the median nerve runs near and parallel to the submedian, it becomes faint and disappears in the apical third of the wing; the submedian has 14 offsets, it reaches to the apex of the wing but becomes very faint. Hind legs much exceeding the abdomen. Abdominal papillæ absent.

Female with the ventral plate of the 7th abdominal segment half as long as broad, the postero-lateral margins slightly concave. The abdomen of the queen reaches a length of 20 mm.; the secondary chitinization is strong and well defined; the lateral cuticle of the abdomen has minute pigment-spots and hairs.

Soldier 4 mm. long. Head and thorax dark castaneous, abdomen isabelline. Head 1 mm. broad. Antennæ 3·5 mm. long, of 14 segments, the 3rd three times as long as the 2nd, the others decreasing towards the apex. Rostrum slender, its anterior surface making a marked curve with the anterior surface of the head. Gula not so long as broad. Pronotum saddle-shaped, the anterior lobe not much raised. Posterior femora not much exceeding the abdomen. Abdomen ovoid, the dorsal plates arched. Abdominal papillæ absent.

Worker 4 mm. long; fuliginous, the head black. Antennæ of 16 segments. Posterior femora reaching to the 8th segment of the abdomen. Abdomen ovoid, laterally compressed, the dorsum much arched.

Nests of this species generally occupy the centre of nests of *T. comis*, and have large entrances situated at the upper part.

Hab. Borneo (Sarawak); Malay Peninsula (Singapore). Type, No. 304.

TERMES RUFUS, n. sp.

Soldier 3·5 mm. long. Head testaceous, darker on the vertex, thorax subtestaceous; abdomen fuliginous, tibiæ ochraceous. Head 1 mm. broad. Antennæ 2·5 mm. long, of 14 segments, the 3rd more than twice as long as the 2nd; the 4th, 5th, 6th, and 7th subequal to the 3rd, the others decreasing in length towards

the apex. Rostrum slender, the anterior surface making a distinct curve with the anterior surface of the head. Rudimentary mandibles easily visible. Gula not so long as broad. Pronotum saddle-shaped, the anterior lobe short, not much elevated. Hind legs exceeding the abdomen. Abdomen ovoid, the dorsal plates not much arched. Abdominal papillæ absent.

Worker 3·5 mm. long. Head and thorax testaceo-castaneous; abdomen fuliginous; legs umbrinous. Antennæ 2·5 mm. long, of 15 segments. Posterior femora reaching to the 8th abdominal segment. Abdomen ovoid, the dorsal plates much arched.

Hab. Malay Peninsula (Perak). Type, No. 115.

TERMES BICOLOR, n. sp.

Nymph with antennæ of 15 segments.

Soldier 3·5 mm. long. Rostrum subtestaceous, head subcastaneous; thorax, legs, and antennæ ochroleucous, abdomen fuliginous. Head 1·4 mm. broad. Antennæ 3·5 mm. long, of 14 segments, the 3rd three times as long as the 2nd, the others decreasing in length towards the apex. Rostrum slender, its anterior surface making a curve with the anterior surface of the head. Rudimentary mandibles easily visible. Gula not so long as broad. Pronotum saddle-shaped, the anterior lobe not much elevated. Posterior femora much exceeding the abdomen. Abdomen ovoid, the dorsal plates much arched. Abdominal papillæ absent.

Worker 3·5 mm. long. Head subcastaneous; thorax and legs ochroleucous; abdomen ovoid, the dorsal plates much arched. Antennæ of 15 segments. Posterior femora reaching to the 8th abdominal segment. Abdomen ovoid, the dorsal plates much arched.

Hab. Malay Peninsula (Singapore, Pulo Brani).

TERMES LONGIPES, n. sp.

Queen castaneous, legs ochraceous. Head ovate. Ocelli approximated to the eyes. Epistoma but slightly convex and prominent. Pronotum with straight anterior margin, rounded antero-lateral angles but slightly deflexed, postero-lateral margins nearly straight. Mesonotum with posterior border broad, markedly concave. Metanotum with posterior border narrower, also concave. Anterior wing-stumps larger than the posterior. Abdomen reaches a length of 20 mm. The plates of secondary

chitinization large and dark castaneous. Lateral cuticle of abdomen with hairs and rather large pigment-spots.

Soldiers of two sizes. The larger 5 mm. long; head castaneous, thorax and abdomen umbrinous, legs and antennæ pale. Head 1·5 mm. broad. Antennæ 3·5 mm. long, of 14 segments, the 3rd segment four times as long as the 2nd, the others diminishing in length towards the apex. Rostrum slender, its anterior surface making a marked curve with the anterior surface of the head. Rudimentary mandibles readily visible. Gula not so long as broad. Pronotum saddle-shaped, with the anterior lobe very short and scarcely raised. Hind femora exceeding the abdomen. Abdomen ovoid, the dorsal plates somewhat arched. Abdominal papillæ absent.—The smaller soldiers 4 mm. long, more slender than the large ones, but similar in colour. Head ·8 mm. broad. Antennæ 3·2 mm. long.

Worker 5 mm. long; head subcastaneous, thorax and abdomen umbrinous, legs and antennæ pale. Antennæ of 15 segments. Posterior femora reaching to the 7th abdominal segment. Abdomen large, ovoid, the dorsal plates much arched.

Hab. Malay Peninsula (Perak); Borneo (Sarawak), (Marudi).

EXPLANATION OF THE PLATES.

Plate 22.

Nest of Bornean White Ant.

Plate 23.

Fig. 1.	*Hodotermes Havilandi.*	Soldier. ×3.
2.	„ „	Underside of soldier's head. ×3.
3.	*Calotermes domesticus.*	Soldier (side view). ×6.
4.	„ „	Underside of soldier's head. ×8.
5.	„ „	Imago. ×6.
6.	„ „	Wing. ×6.
7.	*Termes natalensis.*	Soldier. ×4.
8.	„ „	Underside of soldier's head. ×5.
9.	„ „	Imago. ×4.
10.	„ „	Wing. ×2.
11.	*Termes vulgaris.*	Soldier. ×8.
12.	„ „	Underside of soldier's head. ×8.
13.	„ „	Imago. ×3.
14.	„ „	Wing. ×1½.

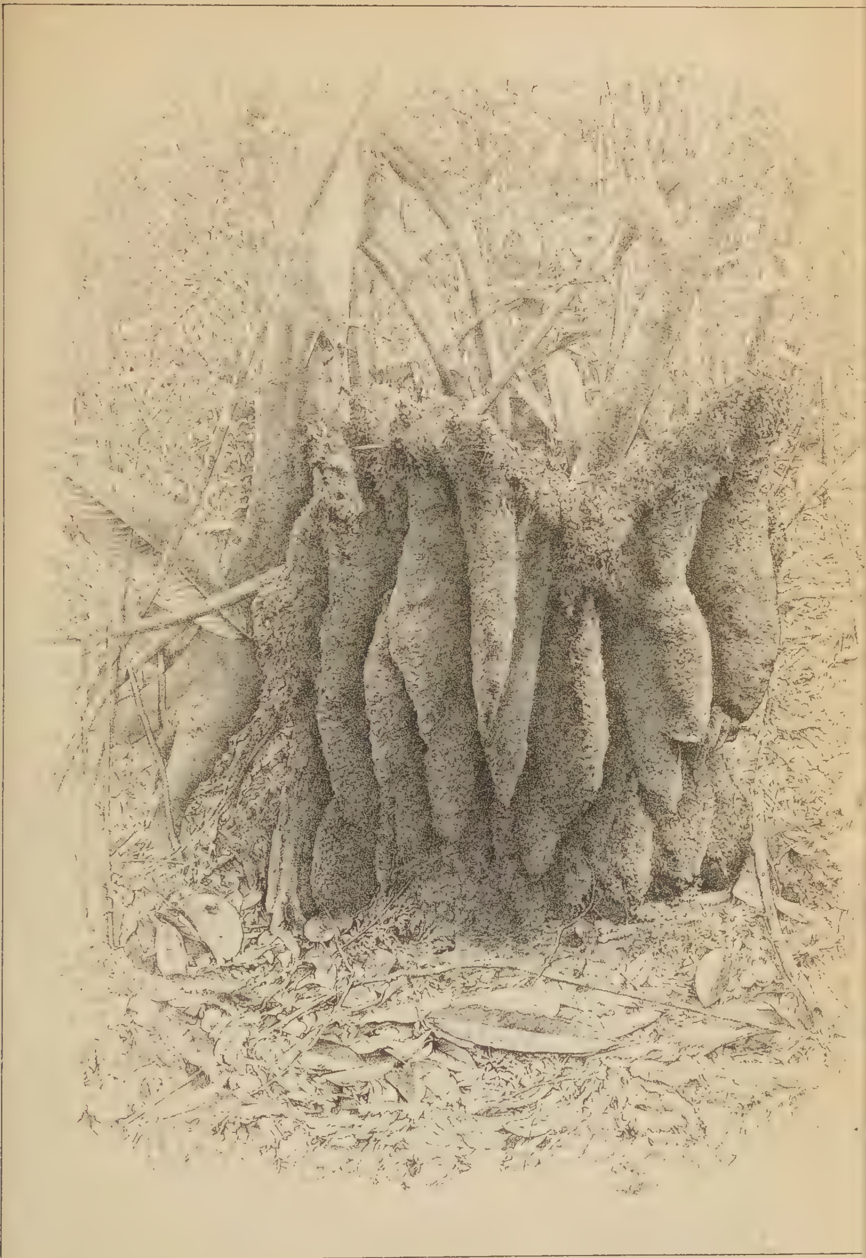
Fig. 15. *Termes incertus.* Soldier. ×8.
16. „ „ Underside of soldier's head. ×8.
17. „ „ Imago. ×4.
18. „ „ Wing. ×2.
19. *Termes travians.* Soldier. ×10.
20. „ „ Underside of soldier's head. ×12.
21. „ „ Imago. ×6.
22. „ „ Wing. ×3.
23. *Termes translucens.* Soldier. ×4.
24. „ „ Underside of soldier's head. ×6.
25. „ „ Imago. ×4.
26. „ „ Wing. ×3.

PLATE 24.

Fig. 27. *Termes æqualis.* Soldier. ×10.
28. „ „ Underside of soldier's head. ×10.
29. „ „ Neoteinic queen. ×5.
30. *Termes planus.* Soldier. ×8.
31. „ „ Underside of soldier's head. ×8.
32. „ „ Imago. ×10.
33. „ „ Wing. ×8.
34. *Termes tenuior.* Soldier. ×8.
35. „ „ Underside of soldier's head. ×8.
36. „ „ Imago. ×8.
37. „ „ Wing. ×8.
38. *Termes dubius.* Soldier. ×8.
39. „ „ Underside of soldier's head. ×12.
40. „ „ Imago. ×8.
41. „ „ Wing. ×6.
42. *Termes sulphureus.* Soldier. ×8.
43. „ „ Side view of soldier's head. ×10.
44. „ „ Imago. ×8.
45. *Termes dentatus.* Soldier. ×8.
46. „ „ Side view of soldier's head. ×8.
47. „ „ Imago. ×6.
48. „ „ Wing. ×4.
49. *Termes bilobatus.* Soldier. ×6.
50. „ „ Side view of soldier's head. ×6.
51. „ „ Imago. ×6.
52. „ „ Wing. ×3.
53. *Termes nemorosus.* Soldier. ×6.
54. „ „ Side view of soldier's head. ×6.
55. „ „ Imago. ×6.
56. „ „ Wing. ×4.

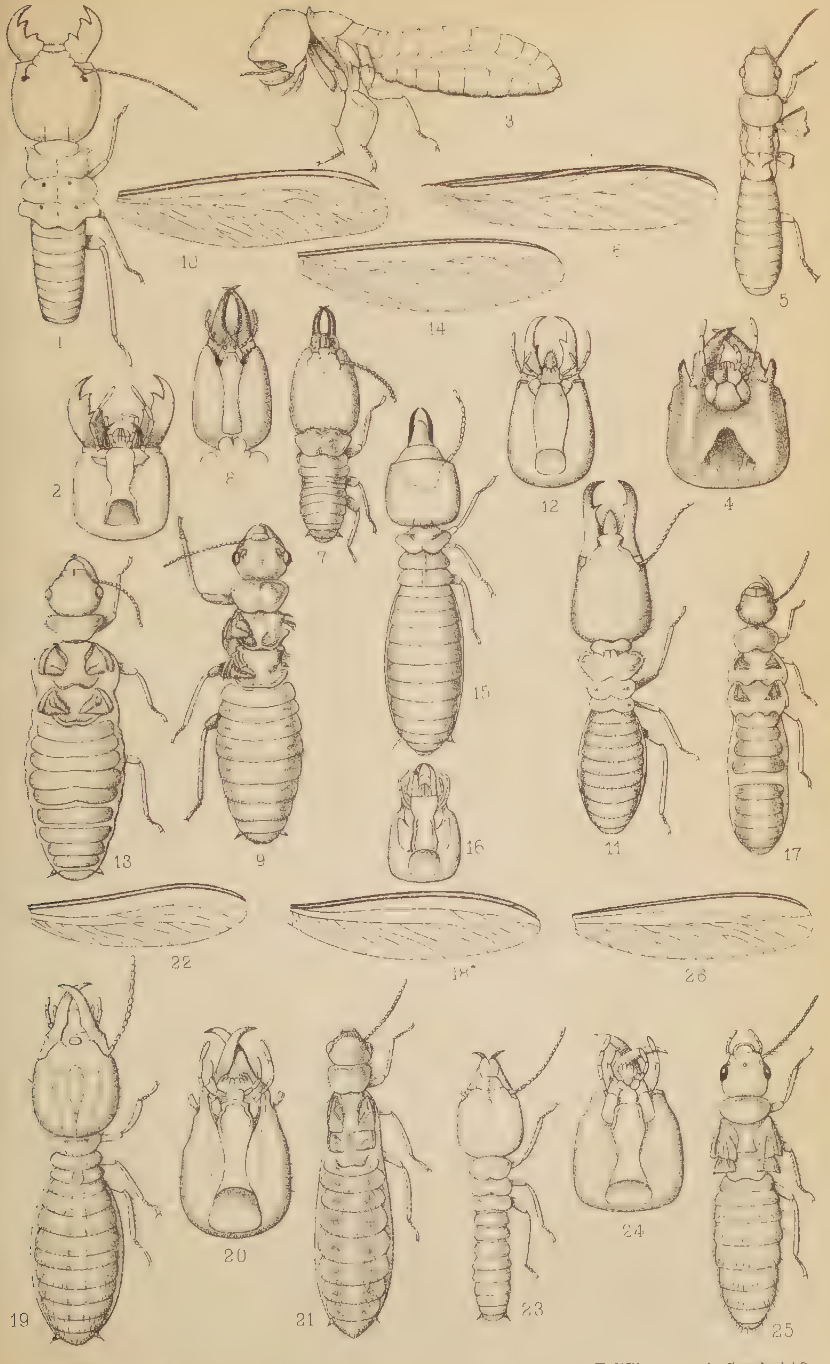
PLATE 25.

Fig. 57. *Termes setiger*. Soldier. ×6.
58. " " Side view of soldier's head. ×8.
59. " " Imago. ×6.
60. " " Wing. ×4.
61. *Termes comis*. Soldier. ×8.
62. " " Side view of soldier's head. ×8.
63. " " Imago. ×8.
64. " " Wing. ×5.
65. *Termes foraminifer*. Soldier. ×8.
66. " " Side view of soldier's head. ×10.
67. " " Imago. ×8.
68. " " Wing. ×6.
69. *Termes fuscipennis*. Soldier. ×8.
70. " " Side view of soldier's head. ×8.
71. " " Imago. ×6.
72. " " Wing. ×3.
73. *Termes regularis*. Soldier. ×6.
74. " " Imago. ×6.
75. " " Wing. ×4.
76. *Termes singaporiensis*. Soldier. ×10.
77. " " Side view of soldier's head. ×10.
78. " " Imago. ×6.
79. " " Wing. ×3.
80. *Termes lacessitus*. Soldier. ×8.
81. " " Side view of soldier's head. ×8.
82. " " Nymph. ×6.
83. *Termes hospitalis*. Soldier. ×8.
84. " " Side view of soldier's head. ×8.
85. " " Imago. ×6.
86. " " Wing. ×3.



Haviland, Photo. E. Wilson, Lith. Cam.

NEST OF TERMITE [illegible] ALLIED
TO T. NEMOROSUS. SARAWAK. SANTUBONG.



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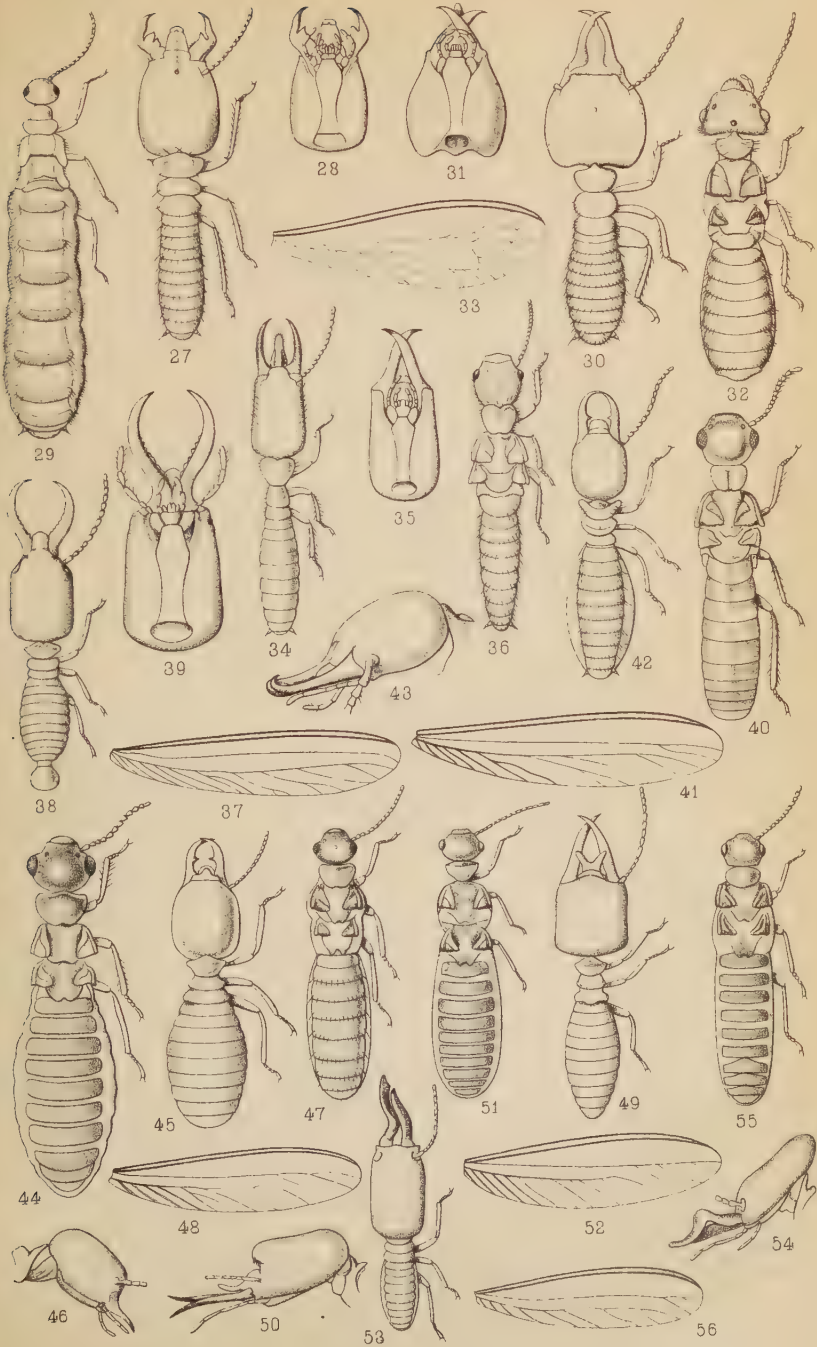
MALAYAN & S. AFRICAN TERMITES.



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MALAYAN & S. AFRICAN TERMITES.

Westwood Bequest. E. Wilson, Lith. Cambridge.

MALAYAN & S. AFRICAN TERMITES.

On *Pontobolbos*, a Remarkable Marine Organism from the Gulf of Manaar.

By ARTHUR DENDY, D.Sc., F.L.S., Professor of Biology in the Canterbury College, University of New Zealand.

[Read 18th November, 1897.]

(PLATES 26 & 27.)

SOME years ago I received from Mr. Edgar Thurston, Superintendent of the Government Central Museum at Madras, a number of Sponges collected in shallow water off the shores of Rámésvaram Island, *i. e.* the Madras coast of the Gulf of Manaar. Among these were fifteen specimens of an organism which at once struck me by its peculiar appearance, and which microscopic examination soon showed to be no sponge. I have lately made a careful investigation into the structure of this organism. At first I felt certain that it was animal in nature, and commenced my investigations from the zoological standpoint. I have, however, been gradually forced to the conclusion that it is, at any rate largely, of Bacterial origin. Not being a bacteriological specialist myself, I feel some diffidence in offering the present paper for publication; but the organism in question is so remarkable, and evidently forms such a conspicuous feature in the marine life of the Gulf of Manaar, while at the same time it presents such a striking resemblance in some respects to certain obscure forms of life usually regarded as animal, that I venture to hope the following description and suggestions may be of some general biological interest.

It seems desirable, for convenience of reference, to propose a new generic name for the organism under discussion, and I therefore name it *Pontobolbos*, from the Greek πόντος, sea, and βόλβος, bulb, in allusion to its marine habitat and concentrically laminated structure. The question of generic diagnosis may be conveniently left to the future.

Pontobolbos manaarensis, n. sp., forms hemispherical or cushion-shaped masses, of a brown colour in the living condition, attached to rocks in shallow water (Pl. 26. figs. 1–4). The size of the spirit-preserved specimens varies from 13 mm. to as much as 36 mm. in diameter, and the colour is pale grey. The upper surface is more or less convex, smooth and even, but very finely granular in appearance. The lower surface, which has been detached from the rock, is more or less flattened or even concave

its exact form no doubt depending upon the nature of the surface on which it lay. One specimen (fig. 3) is irregular in shape, and appears to have been formed by the fusion of three growing side by side. The upper surface occasionally exhibits small round pits, which may be either deep, as in fig. 1 and at *p* in fig. 2, or shallow and pock-like, as at *p* in fig. 4. The latter are especially developed near the margin. It seems certain that these pits are not proper to the organism: there is no canal-system in connection with them, and they are probably due to some external agency, possibly to the action of parasites. Their presence certainly increases the superficial resemblance of the organism to a sponge. The texture, after preservation in spirit, is very compact, tough and like that of indiarubber, and there is a good deal of sand in the deeper layers. When cut in half vertically (Pl. 26. fig. 2) the organism exhibits a very strongly marked, concentrically lamellated structure, although the lamellæ do not show the least tendency to separate from one another. Even a very thick slice in spirit is translucent, and shows to the naked eye that the lamellated appearance is due to the occurrence of thin opaque layers in a transparent ground-substance. These opaque layers evidently mark old surfaces of growth, and the distance between successive surfaces varies considerably, up to about 0·75 mm.

Under a low power of the microscope a tolerably thin vertical section exhibits the appearance shown in Pl. 26. fig. 5. It will be seen that the opaque layers consist of a dense flocculent granular substance, and that they are connected together by a coarse network of similar but less dense material the strands of which ramify, chiefly in a radial direction, through the intervening layers of transparent ground-substance (*cf.* fig. 6). This flocculent material stains fairly readily with borax-carmine, and very intensely with aniline stains such as iodine-green, fuchsin, and methyl-violet. I have not, however, been able to detect any nuclei in it. It also stains faintly yellow with iodine, and more intensely yellow with chlor-zinc-iodide after soaking in iodine. It does not give the xanthoproteic reaction with nitric acid and ammonia, nor does it give the brick-red colour with Millon's reagent, so characteristic of protoplasm, though both these reagents acted satisfactorily upon the protoplasm of fragments of Oscillarian algæ included in the sections.

Frequently irregular layers of much coarser granular material,

which does not stain with any of the above reagents, are met with, as at *l*, *l* in fig. 5. On treatment with sulphuric acid these granular layers dissolve with brisk effervescence and formation of needle-shaped crystals in the neighbourhood: we may therefore conclude with some degree of confidence that they consist of carbonate of lime deposited by the organism. They are not to be confounded with the foreign particles of sand which occur imbedded in the deeper layers as at *g*, *g* in fig. 6.

Careful examination of the transparent ground-substance between the flocculent, deeply-staining material shows that the former is not by any means structureless as it appears at first sight, but contains, or perhaps one should even say consists of, innumerable exceedingly slender unbranched threads, lying close together, and generally, but by no means always, arranged in a radial manner, more or less at right angles to the successive surfaces of growth. These threads are most strikingly brought into view by mounting in chlor-zinc-iodide a thin section previously soaked in a solution of iodine in potassium iodide (Pl. **27**. fig. 7). They then assume a beautiful blue or violet colour, which is also produced by treatment with iodine and sulphuric acid and indicates that they consist, at any rate largely, of cellulose. The threads are only about 0·0018 mm. in diameter, and further examination shows them to be the cellulose sheaths of chains of short, rod-like bacteria. In the deeper layers of the organism nearly all the sheaths are empty, but a few may still contain the chains of bacteria to which they owe their origin (Pl. **27**. fig. 8).

The bacteria themselves are stained yellow or brown by the action of the iodine in the chlor-zinc-iodide method, and are then clearly seen to consist of short rods, somewhat less in diameter than the containing sheath, only about 0·00135 mm., and two or three times as long as they are broad. The size of the rods, however, varies a good deal, as will be seen by reference to fig. 8. As we approach the surface we find more and more of the rods, until in the youngest layer of the colony we have a dense and almost solid mass of more or less felted chains of rods. Thus fig. 9 shows a small portion of a thin vertical section cut by the paraffin method and stained, after drying on the slide, with carbol-fuchsin, followed by iodine. It will be noticed that the chains of rods are very distinct, having taken the stain strongly, but the cellulose sheaths are not visible. This figure

should be compared with fig. 7, showing a portion of one of the deeper layers where all the rods have disappeared and the empty sheaths are brought into view by the chlor-zinc-iodide method.

It appears to me that there are two possible views as to the nature of *Pontobolbos*: first, that the organism is entirely bacterial in origin, the flocculent layers and network being due to the formation of slime or jelly by the bacteria themselves; second, that it is due to symbiosis between the bacteria and some gigantic rhizopod the protoplasm of which is seen in the flocculent layers and network. We may consider these two views separately.

That the great bulk of the entire organism consists of filaments of some Schizophyte and their sheaths, I think has been already sufficiently demonstrated. The filaments appear to be very closely related to *Crenothrix*. *Crenothrix Kühniana* is described as consisting of "cocci, rods and thread-forms. The threads are colourless, 1·5–5 μ thick, and club-shaped at the extremity, reaching a diam. of 6–9 μ. The threads form colonies with a brick-red, olive-green, or dark-brown to brown-black coloration, caused by impregnation with oxide of iron. The threads are distinctly articulated, and ensheathed. The segments are set free when the sheath bursts, and develop into new threads. In other cases the segments remain enclosed, and subdivide into discs, which, by vertical fission, break up into globular forms (cocci). These again develop into new threads, either within the sheath, eventually penetrating it, or after they are set free."

"The micro-organism appears in little whitish or brownish tufts in wells and drain-pipes, and it not only renders drinking-water foul, but may stop up the narrower pipes."

The above description is taken from Crookshank's 'Manual of Bacteriology' (2nd edition, p. 322). The figures showing colonies of threads growing out of a zooglœa of cocci are especially suggestive of a comparison with *Pontobolbos*. The chief differences appear to be that in *Pontobolbos* the threads are more slender and of the same diameter throughout, and that they grow much more closely together to form compact layers on the top of which the zooglœa is presumably passed out from the upper ends of the sheaths. This zooglœa, if such it be, may form the base from which another layer of rods grows

up, so that by repetition of the process a large stratified mass is formed in which the lower layers are composed almost entirely of empty cellulose sheaths and the flocculent staining-material (remains of zooglœa ?).

I have not been able to demonstrate the existence of cocci in the flocculent layers or network of *Pontobolbos*, though I have detected occasional indications of their formation within the sheaths; and the fact that the outermost flocculent layer is already present before the threads in the layer below it have discharged their contents (Pl. 27. fig. 9) seems to indicate that it cannot be entirely due to zooglœa formation. According to Klein *, zooglœa masses always present themselves as uniformly granular, the granules or micrococci being of the same size. The darkly staining layers and network of *Pontobolbos*, on the other hand, are by no means uniformly granular but rather flocculent. They contain granules of various sizes, but comparatively few that are at all sharply defined.

The Bacteria, such as *Leptothrix* and *Crenothrix* especially, are well known to be very closely related to the blue-green algæ (*Cyanophyceæ*) †, and there are certain species of the latter group which are also in some respects pretty closely comparable with *Pontobolbos*.

Such especially appears to be the case with the Oscillarian *Lyngbya* (*Phormidium*) *membranaceum*, which forms firm, leathery layers of a greenish-black or olive colour; with threads 3–8 μ thick, greenish or brownish, and delicate colourless sheaths. The terminal cell is narrowed and often provided with fine cilia at the apex. This species was placed by Kützing in the genus *Phormidium*, distinguished from *Lyngbya* by the fact that the sheaths are grown together to form a firm, often laminated structure. More recent authors, however, appear no longer to keep the two genera apart ‡. This description also is certainly very suggestive of *Pontobolbos*, though the threads are very much thicker. I am not aware, however, that the darkly staining layers and network have ever been seen in a *Lyngbya* or indeed any Oscillarian. If the threads of *Pontobolbos* were really *Lyngbya*

* 'Micro-Organisms and Disease,' p. 60.

† Thus Le Maout and Decaisne include *Bacterium* and *Leptothrix*, together with *Oscillatoria*, *Lyngbya*, and others, in the one family *Oscillatorieæ*.

‡ *Vide* Reinhold, "Die Cyanophyceen (Blautange) der Kieler Föhrde" (Schrift. d. Nat. Vereins. für Schleswig-Holstein, Bd. viii. Heft 2, p. 173).

filaments, it would make it all the more difficult to account for the origin of these layers, for *Lyngbya* is supposed to reproduce by means of motile filaments and not by means of gonidia or cocci, and the zooglœa hypothesis of the origin of the granular layers would accordingly be untenable. The elongated form of the cells in the filaments, however, seems to exclude the idea that we are dealing with a true Oscillarian in the case of *Pontobolbos.* True Oscillarian filaments do occasionally occur as foreign bodies (Pl. 27. fig. 8 *a*), but they offer a striking contrast in appearance to the vastly more numerous filaments which I consider as bacterial (fig. 8).

Another comparison has been suggested to me by Mr. R. M. Laing, M.A., B.Sc., and that is with the calcareous pebbles formed by *Schizothrix fasciculata* as described and figured by Murray *. These pebbles were found at the bottom of a pond in Michigan, and I extract the following account of them from Mr. Murray's interesting paper:—"The specimens vary in size from an inch to three inches and a half in diameter, are hollow in the interior, and show a stratified or concentric-zoned structure. On decalcifying a portion of one, I found that it was composed of a densely interwoven mass of filaments evidently not all of the same nature, but the predominating kind was clearly a species of *Schizothrix*, while mixed with it there were other forms †, notably filaments of *Stigonema* and *Dichothrix.* I examined portions here and there from a number of the pebbles, and in all cases found the strong stout sheaths and filaments of *Schizothrix* composing by far the greater part of the decalcified mass. At the surface the *Schizothrix* filaments had been clearly alive when the pebbles were gathered, while nearer the centre older sheaths only were found. It was apparent that the *Schizothrix* died off internally while fresh crops were produced on the surface adding to the growth of the pebble. . . . *S. fasciculata* is known from the countries of Central Europe, and forms small, stony, cushion-like calcareous masses. The filaments are always entangled where they are incrusted, but on the surface, where they are more or less free, there is very little entanglement and the filaments are almost straight and parallel. The ordinary incrustation formed by this

* Phycological Memoirs, April 1895.

† Compare the occasional occurrence of Oscillarians in *Pontobolbos* (*vide* Pl. 27. fig. 8 *a*).

species is said to be zoned in section, and its surface is generally mammillate."

The resemblance of these calcareous pebbles to *Pontobolbos* is certainly very striking, especially when we bear in mind that the latter also contains a considerable quantity of carbonate of lime. At the same time there appears to be no doubt that the filaments of *Pontobolbos* do not belong to a *Schizothrix*. The case of *Schizothrix*, however, seems to show that somewhat similar filaments are capable by themselves of giving rise to a massive laminated structure without the co-operation of any symbiotic animal organism.

We come now to the consideration of the second hypothesis as to the nature of *Pontobolbos*, viz., that it is a symbiotic organism, consisting of bacterial filaments growing in association with a gigantic Rhizopod. This hypothesis would at once explain the existence of the darkly staining flocculent layers and network, which form by far the most conspicuous feature in sections stained by any of the ordinary methods applicable to animal tissues. Nor is it impossible to point to certain known Rhizopods the structure of which seems to support this view. I refer to some of the large Foraminifera, such as the extinct *Nummulites*, and especially to that remarkable fossil form *Loftusia persica*, described by Carpenter and Brady *, which attains a length of $3\frac{1}{2}$ inches and a breadth of $1\frac{1}{4}$ inches, and exhibits a laminated appearance in section extremely suggestive of *Pontobolbos*.

In *Loftusia*, as in many Foraminifera, the typical calcareous skeleton is replaced by sand. In many siliceous and horny sponges a similar replacement takes place. Indeed, there seems to be a strong tendency, both amongst Protozoa and Sponges, to replace the proper skeleton with foreign material whenever such material is available. They do this in accordance with what might be termed "The Law of Economy in Skeleton-formation."

It is also well known that symbiotic (or parasitic?) Schizophytes are frequently met with in large numbers in Sponges, some of which, indeed, appear to be habitually infested with such forms. Thus Schulze has described* the occurrence of *Oscillaria spongeliæ* in *Spongelia pallescens*, where it occurs even

* Phil. Trans. Royal Soc. 1869, p. 739 (Plates lxxvii. to lxxx.).

† Zeit. wiss., Zool. Bd. xxxii. p. 147.

in the ciliated embryo. Marshall has described * the occurrence of an *Oscillaria* in *Dysidea* (*Psammoclema*) *ramosa*, in which it is noteworthy that he was unable to detect chlorophyll. *Trachycladus lævispirulifer*, again, a common Australian sponge, according to Carter † owes its characteristic red colour to an Oscillarian which has the form of short rods consisting of only four cells each.

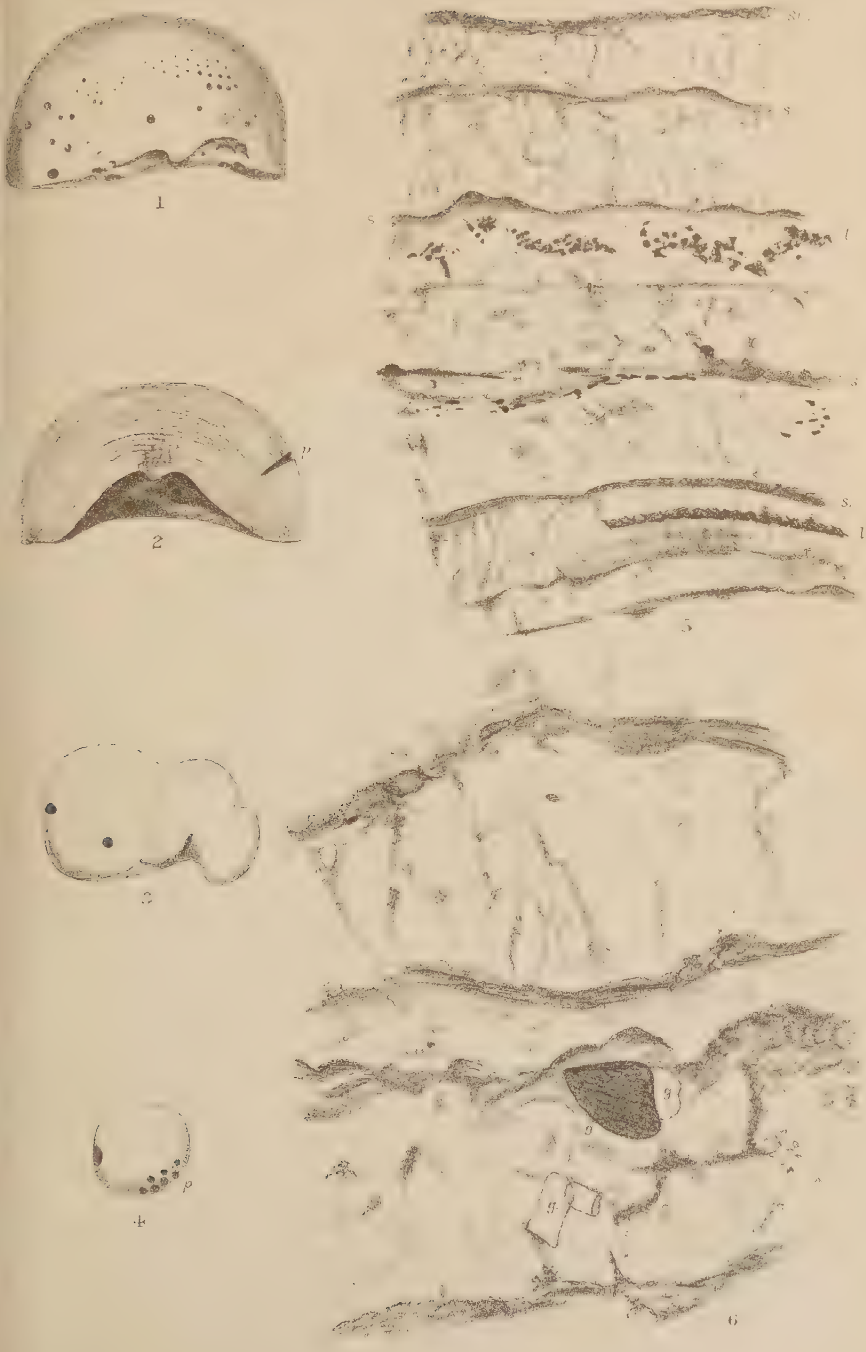
Amongst the Protozoa, many Radiolarians are habitually infested with "yellow cells," now generally believed to be symbiotic Algæ; and, in short, the association of low forms of animal and vegetable life in what is presumably a symbiotic manner is a phenomenon of common occurrence, while the parallel case of the Lichens will occur to everyone.

Assuming that *Pontobolbos* owes its origin to such symbiosis, it is not difficult to see what mutual advantages would be derived by the associated organisms. The Rhizopod gains an admirably firm and tough skeleton of cellulose, and is thus relieved from the necessity of secreting the usual calcareous skeleton. In accordance with the law of economy in skeleton-formation the latter may have disappeared, though possibly the irregular calcareous layers described above may represent the proper skeleton in a vestigial condition. With the proper skeleton, of course, all traces of the chamber-arrangement, so characteristic of the Foraminifera, may be supposed to have disappeared also, if indeed it ever existed. The Schizophyte, on the other hand, being in all probability bacterial in nature and devoid of chlorophyll, may well be supposed to obtain its food-supply at the expense of the Rhizopod.

The chief objections to the hypothesis of symbiosis in the case of *Pontobolbos* lie, first, in the failure, as noted above, to obtain the characteristic protoplasmic reactions with Millon's reagent and with nitric acid and ammonia; and, second, in the failure to detect nuclei in the supposed protoplasmic layers and network. These objections appear to me at present to be very serious, although it must be borne in mind that micro-chemical reactions are not always conclusive, and that nuclei have not yet been detected in all the known lower organisms, while the staining with borax-carmine, aniline dyes, and iodine must also be accounted for. All I have been able to do has been to describe

* Zeit. wiss. Zool., Bd. xxxv. p. 111.

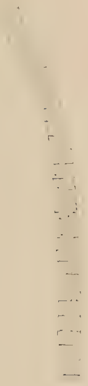
† Ann. & Mag. Nat. Hist. [5] xvi. p. 357.



A.D. del ad nat.
Parker & Percy lith.

Geo West & Sons imp.

PONTOBOLBOS MANAARENSIS.



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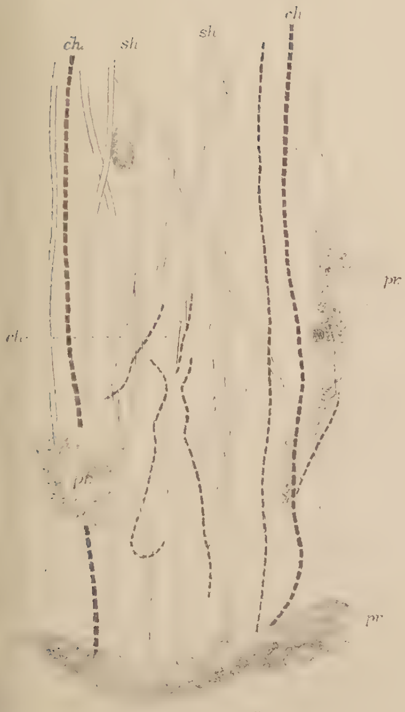

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A. Dendy, del.
Parker & Percy lith.

Geo West & Sons imp.

PONTOBOLBOS MANAARENSIS.

the organism as I found it, to state what appear to me to be the only two possible explanations of its very remarkable structure, and to leave the future to decide which, if either, of these explanations is correct.

In conclusion it may be worth while to refer for a moment to the enigmatical fossil *Stromatoporidæ* *, some of which bear a marvellously close resemblance to *Pontobolbos*, and may quite possibly have been of the same nature.

Christchurch, N. Z.,
June 30, 1897.

P.S.—From the report of the meeting at which this paper was read, I see that Professor Howes found some apparent vestiges of sponge-spicules in the specimen which I forwarded to him for examination. I have not observed any spicules in my own numerous preparations, and am quite sure that those found must have been present simply as foreign bodies. I note also that Mr. G. Murray suggested a comparison with the algal pseudomorphs of sponges described by various authors, but I have seen nothing in the structure of *Pontobolbos* to indicate any connection with a sponge.

Christchurch, N. Z., January 1898.

EXPLANATION OF THE PLATES.

Plate 26.

Pontobolbos manaarensis, gen. et sp. nov.

Fig. 1. The largest specimen, side view. Natural size.

Fig. 2. The largest specimen, vertical section. Natural size. *p*, pit.

Fig. 3. An irregular specimen, formed apparently by union of three growing side by side. Seen from above. Natural size.

Fig. 4. A small specimen seen from above. Natural size. *p*, pits.

Fig. 5. Part of a vertical section cut by hand, stained with iodine-green and mounted in glycerine. Drawn under Zeiss A. Oc. 1. Showing the network of darkly staining material (protoplasm?), the successive surface-layers of the same (*s*), and the irregular layers of calcareous granules (*l*). *s*.1. the outermost layer of the specimen.

Fig. 6. Part of a vertical section stained with iodine-green, cut by the paraffin method and mounted in Canada balsam. Drawn under Zeiss D. Oc. 1. Showing the darkly staining layers and network and a few sand-grains (*g*).

* For a general account of these fossils, see Nicholson and Murie, Journ. Linn. Soc., Zool., vol. xiv. p. 187.

PLATE 27.

Fig. 7. Small portion of a very thin vertical section through one of the deeper layers, mounted in chlor-zinc-iodide after soaking in a solution of iodine in potassium iodide. Drawn under Zeiss D. Oc. 3. *sh*, the empty sheaths of the bacterial rods (stained blue); *pr*, protoplasm? (stained yellow); *o*, fragments of Algæ (stained blue).

Fig. 8. Small portion of a very thin vertical section through one of the deeper layers, mounted in a solution of iodine in potassium iodide. Drawn under Zeiss F. Oc. 1. *ch*, chains of bacterial rods (stained yellow); *sh*, empty sheaths (unstained); *pr*, protoplasm? (stained yellow).

Fig. 8 *a*. Fragment of an Oscillarian found in the same section and drawn to the same scale.

Fig. 9. Small portion of a vertical section, including the outermost layer, cut by the paraffin method and stained with carbol-fuchsin after drying on the slide, followed by iodine and mounted, after again drying, in Canada balsam. Drawn under Zeiss F. Oc. 1. *ch*, chains of rods; *pr*, outermost layer of protoplasm?

On *Haddonia*, a new Genus of the Foraminifera, from Torres Straits. By FREDERICK CHAPMAN, A.L.S., F.R.M.S.

[Read 18th November, 1897.]

(PLATE 28.)

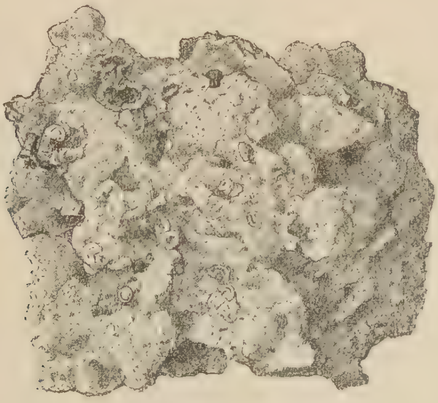
AMONG the many varied types of the Foraminifera, those which are adherent upon foreign bodies are often of peculiar interest, chiefly by reason of the ability of the protoplasmic body of the animal to wander freely over the surface of the object of its support. Such genera, for example, as *Nubecularia*, *Sagenella*, *Placopsilina*, *Bdelloidina*, *Webbina*, *Stacheia*, *Ramulina*, *Vitriwebbina*, *Carpenteria*, *Rupertia*, *Gypsina*, and *Polytrema*, on first acquaintance, were each with more or less difficulty assigned a well-defined position in the Order to which they belong; but as they became more fully understood they were found to exhibit many points of interest in their plans of growth and the structure of their tests, while in their errant condition they sometimes furnished important data for estimating the inter-relationships of other and more exclusive groups.

Many of these adherent Foraminifera find their habitat on coral-reefs and the coral débris derived from them; and the

specimens now to be described were in like manner found on coral-rock.

The original block of rock, on which the new foraminiferal type herein described was found, was collected in 1889 by Prof. A. C. Haddon in the Torres Straits, and on this account I propose for it the generic name *Haddonia*.

For the opportunity of, and facilities for, describing the specimens I am indebted in the first place to Prof. J. W. Judd, C.B., LL.D., F.R.S., who had previously received the coral-rock for the Geological Collection of the Royal College of Science, through Mr. M. F. Woodward of the Biological Laboratory, who had noted it among a collection of corals therein deposited by Prof. Haddon; and subsequently, by the kindness of Messrs. R. Kirkpatrick and H. M. Bernard, I have been furnished with another specimen from the Haddon Collection, now in the British Museum (Natural History), which has helped to complete our knowledge of the chief characters pertaining to the test of the genus.



Specimen of Coral-rock, showing the new Arenaceous Foraminiferon *Haddonia torresiensis*, occurring in association with a *Polytrema*. $\frac{3}{4}$ nat. size.

HADDONIA, gen. nov.

Salient Characters of the Genus.—Test calcareo-arenaceous, adherent, and sinuous; the commencement sometimes straight, sometimes spiral. Chambers imperfectly septate, or openly labyrinthic. Shell-wall coarsely porous.

HADDONIA TORRESIENSIS, sp. nov. (Plate 28.)

Test calcareo-arenaceous, surface rough, of a whitish to yellow or brown colour; consisting of imperfectly septate chambers, their breadth being about twice their height, which are here and there subdivided obliquely, somewhat in the manner of *Textularia*, but very irregularly, the general plan being a moniliform series of segments. The test commences either with a straight or a sinuous series of chambers, or more rarely with a flat coil of a single whorl, after which the chambers are arranged in a more or less rectilinear manner. The test is adherent to coral-rock, fragments of which, with quartz-grains and organisms such as *Discorbina*, fragments of *Polytremata*, and pieces of molluscan shells, are used to construct the shell-wall. The sinuous manner of growth in *Haddonia* is suggestive of a Serpula-tube, and the shell is often bent upon itself. The interior of the test is smooth or even polished, and partially subdivided by imperfect and curved septa (irregularly labyrinthic). The outer wall of the test is perforated by coarse pores such as are seen in *Rupertia* in the hyaline group; and the salient angles of the imperfect septa, which form flying buttresses on the interior of the proper wall, usually show in section a layer of transparent (hyaline) prismatic shell-structure which is non-perforate.

Aperture usually crescent-shaped, sometimes gaping, but more often having a valvular flap, formed by a prolongation of the superior surface of the test, which nearly closes up the orifice as in *Valvulina* and some of the *Miliolinæ*. This apertural flap or valve is in some specimens directed towards the distal end of the test (Pl. 28. fig. 1), but in others towards the proximal end (*cf.* fig. 3); in other words, the organism is sometimes adherent by one side of the flattened and asymmetrical test, and at other times by the relatively opposite side. In the one case the extruding sarcode will be directed towards the surface of attachment, in the other away from it.

The last few chambers also communicate with one another by a curved slit in the middle of the transverse septal wall, when the septation is more than usually complete.

The sarcode when dry is of a rich brown colour (as seen in the recesses of the test of *Haddonia* in a section), with cavernous or honeycomb structure, and bearing here and there fragmentary sponge-spicules, which are adventitious.

Length $\frac{1}{2}$ to nearly $\frac{2}{3}$ of an inch.

On coral-rock, Torres Straits.

F. Chapman del. ad nat.
Parker & Percy lith.

Geo West & Sons imp.

HADDONIA TORRESIENSIS.

Affinities of the Genus.—The specimens above described were discovered on two separate blocks of coral-rock. The organisms appear to have lived on the upper surface of the mass, where they would be exposed to the greater circulation and excitation of the water. The great abundance of specimens of *Haddonia* may be gathered from the fact of there being 31 distinct specimens attached to one of the pieces of rock measuring about 5 × 4 inches *.

The genus, more than perhaps any other I have studied, exhibits points of form and structure in common with several other, and presumably distinct, genera. It falls naturally into the arenaceous group of Foraminifera, by reason of the nature of its test-structure, and appears referable to the labyrinthic group of the subfamily *Lituolinæ*.

The valve-like aperture shows a certain resemblance, if not relation, to the Clavuline and Valvuline groups of the TEXTULARIIDÆ; but although this detail of structure is often of great use in determining the position of the organism, it must be borne in mind that the characters are not always a safe criterion of affinity.

The freedom of growth and the undulating contour of *Haddonia* also call to mind the little-known genus *Bdelloidina* of Carter †, but that has nothing like so complicated a shell-structure as *Haddonia*.

With regard to the coarse porous nature of the shell-wall, it has been already remarked that in this respect this genus shows a similarity to *Rupertia*. And, indeed, on examining the dried sarcode of *Haddonia* under a high power, sponge-spicules were detected in the substance of the protoplasm, which pointed to still further relationship with the group to which *Rupertia* belongs.

The presence of sponge-spicules in the sarcode of *Polytrema* and *Carpenteria* is well-known; and on this account the latter genus was at first believed by its discoverer Dr. J. E. Gray, and also by Dr. Carpenter, to typify an annectant animal form between the Rhizopods and the Sponges.

Although these broken sponge-spicules are normally present in the sarcode, they are sometimes found embedded in the

* Associated with *Haddonia* upon the same block were other Foraminifera, as *Polytrema*, *Carpenteria*, and *Gypsina*.

† Ann. & Mag. Nat. Hist. ser. 4, vol. xix. (1877) p. 201, pl. xiii. figs. 1–8.

structure of the test, being presumably caught up in its growth. The probable use of these spicules in *Haddonia*, as in the other genera mentioned, would seem to be for the stiffening and support of the sarcode, whether within the chamber-cavities or at the points of extrusion, as in *Polytrema*.

EXPLANATION OF PLATE 28.

Fig. 1. *Haddonia torresiensis*, gen. et sp. nov. A typical specimen. Apertural valve situated on the upper surface of the test. ×6.

Fig. 2. *Haddonia torresiensis*. A specimen with a spiral commencement. The end of the test is broken away, and shows the open labyrinthic structure. ×6.

Fig. 3. *Haddonia torresiensis*. Apertural end of test, showing valve-like opening; the valve in this instance is situated nearer the attached surface of the test. ×9.

Fig. 4. Section through the shell-wall of *Haddonia torresiensis*. *o*, the external surface of the test; *i*, the inner surface; *b*, the hyaline shell-layer; *p*, the coarse pores in the shell-wall. ×60.

Fig. 5. A fragment of the dried sarcode of *Haddonia torresiensis*, highly magnified. *c*, irregular cavities in the sarcode, probably due to drying; *s*, a sponge-spicule embedded in the sarcode. ×332.

On some Points in the Anatomy of *Caudina coriacea*, Hutton.

By ARTHUR DENDY, D.Sc., F.L.S., Professor of Biology in the Canterbury College, University of New Zealand.

[Read 2nd December, 1897.]

(PLATE 29.)

THE occurrence of small projections arranged, usually in groups, around the anus * has been known for a long time, but comparatively little light has yet been thrown upon their exact nature. It has, indeed, been recognized that these projections are of two kinds, *anal teeth* and *anal papillæ*. The former occur as calcareous plates or scales, radial or interradial in position †; the

* I use the term *anus* in accordance with the usual custom, though *cloacal aperture* would doubtless be more appropriate.

† *Vide* Ludwig's "Echinodermen" in Bronn's 'Klassen und Ordnungen des Tr-hiereichs,' p. 141.

latter as more or less elongated, tentacle-like projections, with or without calcareous deposits in their walls.

In the apodous family *Molpadiidæ* anal papillæ have been frequently recorded, and Ludwig appears to have been the first to suspect * that these structures represent modified tube-feet or ambulacral papillæ. To Gerould, however, is due the credit of definitely proving † that the five minute finger-like papillæ, which surround the anus in *Caudina arenata*, are in direct connection with the radial ambulacral vessels and are indeed homologous with the terminal tentacles of Asteroids and other Echinoderms. Gerould also found a pair of short, blind diverticula coming off from the radial ambulacral vessel or canal just in front of the terminal tentacle, and considered, no doubt correctly, that these indicate the former existence of a pair of tube-feet, which now, however, no longer project beyond the surface of the body.

The remarkable genus *Caudina* is represented in New Zealand waters by *C. coriacea*, Hutton. In this species Théel described ‡ the existence of five groups of from five to seven papillæ surrounding the terminal anus; one papilla in each group having a very well-developed calcareous skeleton, and possibly representing an anal tooth. He gives, however, no details as to the structure or relations of these organs, and when I first examined the species myself I did not succeed in detecting them §. Since then, however, I have obtained a much more abundant supply of well-preserved material, having found hundreds of young specimens || thrown up on the beach at New Brighton, near Christchurch, N.Z., and having also received some interesting fragments of very young specimens dredged by Mr. H. Suter in Lyttelton Harbour. The study of this material has proved that the "anal papillæ" in *Caudina coriacea* are very much better developed than in *C. arenata*, and has induced me to offer for publication the following account of these interesting organs.

* *Loc. cit.* p. 100.

† *Vide* Gerould, "The Anatomy and Histology of *Caudina arenata*." Bull. Mus. Comp. Zool. Harvard, vol. xxix. p. 164.

‡ *Vide* 'Challenger' Holothurioidea, p. 47.

§ *Vide* "Observations on the Holothurians of New Zealand." Journ. Linn. Soc., Zoology, vol. xxvi. p. 29.

|| One of these specimens is represented of natural size in Pl. 29. fig. 13. It is very small as compared with the adult.

A general description of the external form and internal structure of *Caudina coriacea* has been given by me in my paper on the Holothurians of New Zealand already referred to, while a much more detailed account of the anatomy and histology of the closely allied *C. arenata* has recently been published by Gerould *, so that it is unnecessary to describe the general anatomy in this place. As *Caudina* is still a comparatively little-known genus, however, I may be allowed to remind the reader that the body has a very peculiar form, consisting of an inflated, ovoid, anterior portion, bearing the mouth and tentacles in front, and a narrow, cylindrical, posterior portion, sometimes known as the "tail," with the anus situated at its extremity. Fig. 13, Pl. 29, though taken from a young and consequently very small specimen, exhibits the characteristic form of the species.

The extreme tip of the tail of a very young specimen, dredged in Lyttelton Harbour, exhibited the appearance shown in fig. 1. It will be seen from this that the anus (*a*) is surrounded by five somewhat triangular groups of papillæ, which I shall presently show to be radial in position. Each group consists of one larger projection, placed next to the anus and forming the apex of the triangle, and (usually) seven smaller papillæ, of which one is placed exactly in front of the larger projection, while the others are arranged in two diverging rows of three each on either side, the most anteriorly placed being the smallest. The five larger projections may have been those to which Théel referred as perhaps representing anal teeth; and I shall show later on that they are indeed quite different in structure from the others, and that they are apparently present only in very young individuals. As Théel observed, these five larger projections contain a specially well-developed skeleton, consisting of densely packed, irregularly branched spicules. As development goes on, however, they seem to disappear completely, while the other papillæ may even increase in number, for in one adult specimen I counted as many as nine of them in a group. Figure 2 represents a group of these finger-shaped papillæ, which I propose in future to speak of as *anal tentacles*, from a specimen still quite small, though apparently older than that from which fig. 1 is taken. There are only six tentacles in this group, one of the most

* *Loc. cit.*

anterior being on one side presumably as yet undeveloped. It will be seen that the largest tentacle is placed most posteriorly in the middle of the group. It is strictly radial in position and evidently corresponds to the terminal tentacle of Gerould, being homologous, as that author has pointed out, with the terminal tentacle of Asteroids. It will also be seen that there are no suctorial disks and no end-plates, but that the larger tentacles, in this respect unlike those of *C. arenata*, contain irregularly branched spicules scattered in their walls. In the specimen from which fig. 2 is taken no trace was visible of anal teeth, the five projections which are supposed to represent them having completely disappeared, nor have I found them in any but the very youngest individuals. The specimens in which Théel discovered them appear to have been mere fragments of tails; and we must assume either that these also belonged to extremely young individuals or that he was referring to the five largest anal tentacles, unless it be that the teeth persist in some individuals and not in others.

Having thus described the external appearance of the organs surrounding the anus, we may pass on to investigate their relations to the internal structures. This may be done by means of a series of transverse sections of the so-called tail of one of the youngest specimens.

The general arrangement of the parts concerned is shown in Pl. **29**. fig. 3, which represents a transverse section taken at some little distance in front of the anus (the 80th section from the posterior extremity).

It will be seen that the integument is here very thick, and that the cloaca is attached to the body-wall by very numerous radiating bands of muscle. These deserve a brief notice. Each consists of a hollow cylinder of fibres running lengthwise side by side, and covered externally by a thin layer of epithelium containing many conspicuous, darkly-staining nuclei.

Gerould describes in *Caudina arenata* certain muscle-cylinders which run outwards through the connective-tissue layer of the integument and terminate immediately beneath the epithelium. He points out that the striking resemblance of these muscular tubules to the vessels which connect the ambulacra with the radial canal, led Semper to the erroneous conclusion that they are actually in connection with the canal. Gerould himself

found no such connection, but found the muscle-tubules or cylinders directly continuous with the transverse muscles of the body-wall. He suggests, however, that they may be rudimentary ambulacral vessels, the central ends of which have lost their primitive connection with the radial canal and have secondarily become united to the transverse muscles of the body-wall. He inclines towards this view on account of the arrangement of the fibres in a hollow cylinder, but this hypothesis appears to be now completely negatived by the discovery of a similar tubular structure in the radiating muscles which connect the cloaca with the body-wall in *Caudina coriacea.*

The radiating bands of muscle to a large extent obliterate the body-cavity in the tail-region, but a portion of the cœlom remains conspicuous as a distinct canal (figs. 7, 8, *c.c.*) surrounding the inner aspect of each of the five radially-placed longitudinal muscles. These longitudinal muscles (*r.m.*), as usual, form a very conspicuous feature in transverse sections. Each is composed for the greater part of its length of two almost separate halves running side by side, separated from one another by a deep fissure continued outwards from the cœlomic canal (fig. 7, *c.c.*) just mentioned. The surface of the longitudinal muscle is covered by a distinct layer of epithelium which exhibits a very marked thickening on its inner aspect, as shown in fig. 7. This thickening may be due to the contraction of the muscle having thrown the epithelium into folds, but if so, it is difficult to account for its occurrence on the inner aspect of the muscle only. I am inclined to think, however, that it is more likely the expression of a mass of proliferating epithelial cells from which the very numerous corpuscles of the cœlomic fluid may be derived. Fig. 7 shows four of these corpuscles (*corp.*) in the cœlomic canal at the side of the longitudinal muscle. I have already described them in some detail in my "Observations on the Holothurians of New Zealand." *

Immediately on the outside of the longitudinal muscle-band lies the radial ambulacral canal or vessel (figs. 7–9, *r.a.*), lined by distinct epithelium, and with a layer of longitudinal muscle-fibres on its outer aspect. Outside this lies the radial blood-sinus or lacuna, which is extremely small and ill-defined, often not recognizable as a distinct cavity, but shown pretty clearly in some sections (figs. 8, 9, *r.s.*). Outside this again lies the radial

* Page 31.

nerve-cord with its associated cœlomic canals *. The nerve-cord is as usual divided into inner and outer bands, separated from one another by a thin layer of connective tissue. In the inner band (fig. 7, *i.b.*) the nerve-cells are aggregated on the inner aspect, and in the outer band (fig. 7, *o.b.*) they are aggregated on the outer. Between the inner band and the blood-sinus lies the hyponeural † cœlomic canal (figs. 7 & 9, *hyp.*). Outside the outer band lies the epineural cœlomic canal (*ep.*).

If we trace these various radially-placed organs to the hinder extremity of the body, we find that they terminate respectively as follows:—The longitudinal muscle-band gradually diminishes in thickness, the fissure between its two halves disappears (fig. 8) and the muscle then dies out (figs. 5, 9, 10, 11), its place being taken by bands of transverse fibres (figs. 5, 10, 11, *t.m.*) placed in the radii around the anus, and continuous with the inter-radially-placed transverse or circular muscle-bands. Just posterior to each radially-placed transverse muscle-band the integument projects to form a supposed vestigial anal tooth, which consists of a solid mass of connective tissue containing spicules and surrounded by the epidermis (figs. 1, 6, 12, *t.*).

The radial ambulacral vessel, after the termination of the longitudinal muscle, increases greatly in diameter (fig. 9, *r.a.*) and gives off two or three wide branches on each side (figs. 5, 10, 11, *amp.*). The main trunk and its branches terminate respectively in the central and lateral anal tentacles of each group (fig. 12). Just before it gives off its lateral branches, the radial ambulacral vessel appears to lose the layer of muscle-fibres from its outer aspect (fig. 9), but these appear again after the division has taken place, as a very distinct layer of longitudinal fibres on the outer aspect of each branch (fig. 11, *m.f.*). At first the swollen branches of the ambulacral vessel appear to partake somewhat of the nature of ampullæ, and they probably function as such in controlling the protraction and retraction of the anal tentacles, by forcing liquid into them or causing it to be withdrawn. It will be seen from a comparison of figs. 11 and 12, that in the specimen from which the sections were taken, these

* It seems pretty safe to assume that these canals are cœlomic, although I believe that their derivation from the body-cavity has not been definitely established.

† "Pseudohæmal canal" of some authors, "hyponeural canal" of Gerould.

circumanal ampullæ* were in a state of dilatation while the tentacles themselves were in a state of contraction. It will also be seen from figs. 5 and 11 that the circumanal ampullæ contain a large number of nucleated corpuscles (*corp.*), which shows that they must have been filled with liquid at the time of the animal's death. In the contracted anal tentacles themselves the ambulacral vessels appear as narrow cavities surrounded by an inner epithelium, outside which lies a layer of very slender longitudinal muscle-fibres difficult to recognize, and then a very delicate outer epithelium (fig. 12).

I have not been able to trace the radial blood-sinus or lacuna beyond the point where the ambulacral vessel gives off its lateral branches. Gerould, however, in the case of *Caudina arenata*, states that the radial blood-lacunæ communicate with a circular lacuna surrounding the anal opening. He also figures † what appears to be an immense dilatation of the radial blood-lacuna, occupying almost the entire cavity of the anal papilla or terminal tentacle.

Up to the point where the radial ambulacral vessel gives off its branches to the anal tentacles, the radial nerve maintains its typical structure, consisting of an inner and an outer band accompanied respectively by the hyponeural and epineural canals (fig. 12). Shortly after the ambulacral vessel divides, however, the inner nerve-band dies out, leaving only the outer band, which also divides into branches, one of which accompanies each branch of the ambulacral vessel into an anal tentacle (figs. 11, 12). The epineural canal (fig. 11, *ep.*) also divides, and its branches accompany the corresponding nerves for some distance, but afterwards disappear. At first also each branch of the ambulacral vessel, where it swells out to form an ampullary organ, is accompanied on its outer aspect by a distinct canal, lying outside the layer of longitudinal muscle-fibres and inside the nerve (fig. 11). Whether these canals are derived by a branching of the hyponeural canal or by sudden enlargement and branching of the radial blood-sinus, I have been unable to determine owing to

* As I am not aware that ampullary organs have hitherto been described in this position, I have ventured to distinguish them by the term "circumanal ampullæ" from the numerous other ampullæ which occur in the body of a Holothurian.

† *Loc. cit.* plate iv. fig. 50.

the minuteness and ill-defined character of the parts in question. Just before the inner nerve-band dies out, there appears to be only a single space between it and the circumanal ampullæ (fig. 10). This may be a continuation of the hyponeural canal or a sudden enlargement of the radial blood-sinus. It is a noteworthy fact that it may contain numerous corpuscles (*corp.* fig. 10) similar to those in the adjacent ampullæ.

The chief conclusions arrived at in this paper may be summed up as follows :—*Caudina coriacea* possesses two kinds of papillæ at the hinder extremity of the body around the anus. (1) Five blunt radially-placed projections, which contain abundant spicules and are mere solid processes of the body-wall, without nerves or ambulacral vessels. These projections are apparently present only in extreme youth, and may represent anal teeth in a vestigial condition. (2) Five radially-situated groups of anal tentacles, containing branches of the radial nerves and of the radial ambulacral vessels, and with loosely scattered spicules in their walls. The branches of the ambulacral vessels are swollen out to form circumanal ampullæ, the function of which is evidently to assist in protraction and retraction of the anal tentacles.

The anal tentacles are doubtless homologous with the tube-feet of typical Holothurians, which have undergone a change of function and now serve as tactile organs. Gerould has described how *Caudina arenata* often lives buried in the sand, with only the tip of the tail projecting. Under these circumstances one can well understand the development of sensory tentacles around the aperture, which is not only an anus but also the entrance to the respiratory organs. *Caudina coriacea* doubtless has a similar habit, and this peculiar mode of life may also serve to explain how it was that the dredgings of the 'Challenger' in Cook Straits and of Mr. Suter in Lyttelton Harbour only brought up fragments of the "tail," these having apparently been cut off by the dredge while the body remained buried in the sand or mud.

Christchurch, N.Z.,
August 27, 1897.

DESCRIPTION OF PLATE 29.

CAUDINA CORIACEA, *Hutton.*

Fig. 1. Posterior extremity of a very young specimen viewed as an opaque object, showing the anus surrounded by the five groups of "anal papillæ." (From a "tail"-fragment dredged in Lyttelton Harbour.) $\times 30$.

Fig. 2. Group of anal tentacles of an older but still young specimen, viewed as a transparent object. Zeiss D. Oc. 1.

(Figs. 3–12. Transverse sections of the "tail" of fig. 1, numbered from the posterior extremity forwards.)

Fig. 3. The 80th section. Zeiss A. Oc. 1.

Fig. 4. The 18th section. Zeiss A. Oc. 1.

Fig. 5. The 8th section. Zeiss A. Oc. 1.

Fig. 6. The 3rd section. Zeiss A. Oc. 1. (Reversed as compared with fig. 1.)

Fig. 7. Radial portion of the 79th section. Zeiss D. Oc. 1.

Fig. 8. Radial portion of the 18th section. Zeiss D. Oc. 1.

Fig. 9. Radial portion of the 13th section. Zeiss F. Oc. 1.

Fig. 10. Radial portion of the 10th section. Zeiss D. Oc. 1.

Fig. 11. Radial portion of the 8th section. Zeiss D. Oc. 1.

Fig. 12. Radial portion of the 3rd section, showing only a group of anal tentacles and a vestigial anal tooth. Zeiss D. Oc. 1.

Fig. 13. Entire young specimen from New Brighton Beach. Natural size.

Reference Letters.

amp. Ampullary dilatations of the branches of the radial ambulacral vessels (circumanal ampullæ).

c.c. Cœlomic canals partially surrounding the longitudinal muscles.

cl. Cloaca.

cm. Circular muscles.

corp. Corpuscles.

ep. Epineural canal.

hyp. Hyponeural (pseudohæmal) canal.

i.b. Inner band of radial nerve.

m.f. Muscle-fibres cut across.

o.b. Outer band of radial nerve.

r.a. Radial ambulacral vessel.

r.m. Radial longitudinal muscle.

r.n. Radial nerve.

r.s. Radial blood-sinus.

sp. Spicules.

t. Supposed vestigial anal teeth.

t.a. Ambulacral vessel of anal tentacle.

ten. Anal tentacle.

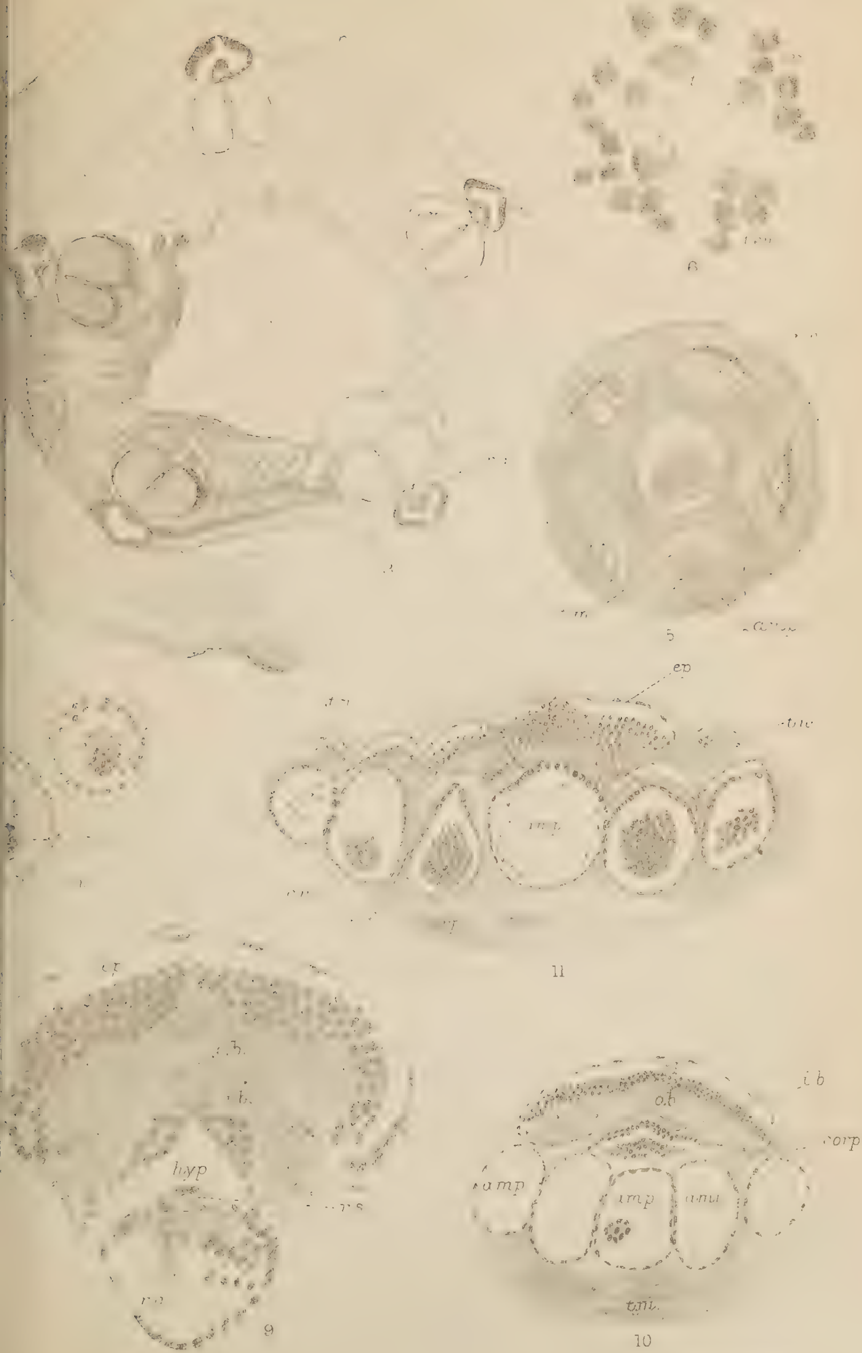
t.m. Transverse muscles.

t.n. Nerve of anal tentacle.

Note.—The *sections* were cut from a specimen treated with borax-carmine and acid alcohol, and the spicules are therefore not shown.

A Dendy del
A.R.Hammond lith.

CAUDI



E.A. Hutton.

West, Newman imp.

On a probable Case of Protective Coloration in the House-Mouse (*Mus musculus*, Linn.). By H. Lyster Jameson, B.A. (From the Biological Laboratory, R. College of Science, London.) *

[Read 2nd December, 1897.]

(Plate 30.)

The colony of Mice I am about to describe was found by me in October 1895, inhabiting the sandhills on the North Bull, Dublin Bay.

This tract of sandhills runs along the coast for about three miles, from Clontarf to Sutton, on the north side of Dublin Bay. A tidal channel of considerable breadth, averaging, I should say, about a quarter of a mile across, separates the sandhills from the mainland at high water, giving place to extensive mud-flats at low tide. A narrow strip of water about 20 yards wide, however, always intervenes, fed by a couple of small streams on the Dollymount shore. A bridge has been built connecting the west end of the island with the mainland, and here also is the North Bull wall, a breakwater running out across the mouth of the Liffey for about a mile, built in 1823. A coastguard station, a cottage, and a golf club-house are the only buildings on the island.

On the 6th of October, 1895, when walking on the sandhills, I observed some mice running about that harmonized strikingly in colour with the sand, appearing to be of an unusually pale tint. I had the good fortune to capture one of these, and found it to be a pale example of *Mus musculus*, Linn. Encouraged by this discovery, during the following week and on various subsequent occasions as opportunity allowed, I set "Cyclone" traps and was rewarded by obtaining thirty-six specimens, a very large proportion of which were considerably paler than the typical *Mus musculus* as it occurs in houses and farmyards in Ireland and England. These specimens, as might be expected, varied somewhat in shade of fur among themselves, and my series shows every gradation from the typical *Mus musculus* to the individual which I have numbered 30 in the following list and in my collection, that being the most extreme case of pale coloration. Striking as is the light colour of the dorsal surface in this race, it is still more unlike *Mus musculus typicus* in the ventral fur, which in the majority of cases is pale

* Communicated by Prof. G. B. Howes, Sec. Linn. Soc.

buff or yellowish white, resembling that of some of the wild subspecies that have been described from various localities (see Thomas 1, Barrett-Hamilton 2), rather than the smoky grey with which we are familiar in the domestic race.

In dimensions this variety agrees with *Mus musculus*, as will be seen from a perusal of the following table, in which the specimens have been arranged according to colour, No. 1 being indistinguishable from the domestic form, and No. 30 the palest of all. Ncs. 31–36 are also very pale, but have been separated from the rest as immature.

Dimensions.

No.	Sex.	Head and body. mm.	Tail. mm.	Hind foot. mm.	Ear. mm.
1.	♀	90	76	18	
2.	♂	82	75	18	
3.	♀	78	75	19	
4.	♂	87	75	18	
5.	♀	Measurements lost.			
6.	♂	77	74	17	
7.	♂	75	78	18	
8.	♂	Measurements lost.			
9.	♂	80	82·5	18·5	
10.	♂	69	76	16	12
11.	♂	83	87	18	13
12.	♂	63	69	17	11
13.	♂	80	74	17	13·5
14.	♀	Measurements lost.			
15.	♀	65	70	17·5	
16.	♂	72·5	71	16	
17.	♀	94	95	16·5	13·5
18.	Label lost.				
19.	♀	80	80	17	12
20.	♂	80	78	17	12
21.	♀	75	80	16	12
22.	♀	88	84	17	13·5
23.	♀	78	79	18	12
24.	♀	88	79	17	13
25.	♂	82	82	17	13
26.	♂	88	76	16·5	13
27.	♂	84	86	18	12
28.	♂	64	66	18	12
29.	♂	80	75	17	12
30.	♂	75	73	17·5	
31.	♂	45	50	16	7
32.	♂	78	83	17	12
33.	♀	45	48	16	7
34.	♂	Measurements lost.			
35.	♂	60	56	15·5	
36.	♂	52	51·5	15·5	13

Colour.—Nos. 1–5 are quite as dark as average specimens of

Mus musculus from the mainland of Ireland and from Great Britain. Some of the specimens I compared them with were trapped in corn-fields in the Eastern Counties of Ireland, and are certainly not "smoke-stained" as is so often the case with mice caught in houses. From No. 6 onwards they grow gradually lighter, both dorsally and ventrally. No. 9 shows a distinctly rufous colour dorsally, but has the grey belly of the House-mouse; No. 10, but slightly lighter than No. 9 dorsally, has a very white belly; and from this point onwards through the series the mice are all various shades of rufous or fulvous grey dorsally, and with the exception of one or two, that retain traces of the grey belly of their ancestors, they are pale buff ventrally. In Nos. 20, 23, 24, 29, and 30 the grey bases to the hairs on the ventral surface have almost or completely disappeared. The specimens numbered 10 to 36, *i. e.* all the markedly pallescent individuals, can be broadly described in the following terms:—Dorsal fur much paler than in the domestic type; rufous grey or fulvous grey is the usual colour. Ventral surface pale buff, separated from the darker dorsal fur by a more or less clean-cut line. The slaty-grey bases to the hairs which characterize *Mus musculus typicus* are usually, but not always, reduced both in shade and in extent. All over the body, on the ears and tail, the hairs are generally lighter and more fulvous than in *Mus musculus typicus*; the ears, nose, and tail are also lighter. The feet are white, or pale buff, in all cases; in the ordinary House-mouse they vary from smoky-grey to white. The claws are flesh-coloured; the eyes dark brown. Many of these mice, however, do not fulfil all these requirements, intergrading in some one or more characters with the darker mainland form; but everybody will admit the difficulties that beset one in describing an unstable aberration that has not yet become stereotyped into a constant subspecies or species. Notwithstanding the perfect intergradation, the mean colour of this race is not only lighter than that of the type, but is lighter than most, if not all, of the light-coloured subspecies of *Mus musculus* which are preserved in the British Museum.

During October 1875, I made the following observations on the habits of the mice. They live in burrows in the sand, often of a considerable depth. The nest is made in a chamber of such a burrow; I dug out three of these nests, all of which were from two to three feet from the entrances, and had several

passages leading from them. Two of them were made entirely of blades of bent-grass (*Ammophila* [*Psamma*] *arenaria*), the third of tidal refuse, straw, paper, and feathers. I found one mouse in a hole only a few inches deep, outside which was a heap of freshly thrown-up sand; there can be no doubt it was in the act of burrowing, which proves that they make their own holes; indeed, on the North Bull there is no other mammal to make them. This fact is of interest, as, if *Mus musculus* in the wild state uses the burrows of other animals as Thomas suggests (**1**), we have here a habit that has been acquired by these mice since they colonized the island, to enable them the better to escape from their enemies.

They are very numerous; the sandhills are in places riddled with their burrows, and the island is probably stocked with as many mice as it can support, for I found in several cases the mice I trapped had been devoured more or less completely by the survivors.

Presumably they live on the seeds of such plants as grow on the sandhills, and on the varied diet of city offal cast up on the sands from the mouth of the Liffey. At dusk I more than once observed mice among the refuse left at high-water mark.

They are probably quite as prolific as their darker domestic ancestors; the uterus of one female contained nine fœtuses. The numerical increase must be very much accelerated by the absence of terrestrial scent-hunting enemies.

Running very rapidly over the sand, these mice are almost impossible to follow with the eye, so perfectly do they harmonize with their surroundings.

When we come to enquire into the factors which have led to the evolution of this race, we have not far to look. The short-eared owls, which in autumn and winter always frequent the sandhills, as well as the numerous hawks that come over from the mainland, and can be seen any day in pursuit of prey on the North Bull, most readily capture those mice which contrast most strongly with the sand and the arid vegetation peculiar to such places; in short, they pick out the darker mice. The very scanty cover, and the probability that the mice have to travel some distance for their food over bare sand, make the dangers to dark and conspicuous mice much greater.

Under these circumstances, coupled with the fact that the hawks and owls hunting by *sight* are the only enemies these

mice have to cope with, it is very natural that a protectively coloured race should be gradually supplanting the dark one that gave rise to it.

Isolation, no doubt, has also been a very important factor in intensifying the effects of competition; the absence of direct communication with the mainland, and the consequent impossibility of frequent immigrations of dusky specimens from the houses on the adjoining shore, have allowed Natural Selection to carry on its weeding-out of unfavourable variations without disturbances of any kind. The immigrations (if any) from the mainland, by swimming or by the bridge (which is made of open woodwork and of considerable length), must be so very exceptional, that their effects on the colony need not be considered.

The alternative explanations which might be suggested do not seem to me very hopeful. The objection that there may be no causal relation between the factors I have enumerated and the paleness of the mice, can only be established or refuted by a study of the mice inhabiting similar sandy islands elsewhere. Should similar races be found on such islands, the relation would be at once established. That this colony may represent the descendants of some foreign subspecies, introduced in a ship, is unlikely when we remember the perfect intergradation between our variety and the type.

It was suggested to me that in Ireland we might have a wild form of *Mus musculus*, as well as the introduced domestic race that alone occurs in Great Britain. The known subspecies have recently been enumerated by Barrett-Hamilton (2). First, comparing the Clontarf mice with Thomas's wild race from Portugal, the dimensions of the former agree with *Mus musculus*, not with Thomas's race (1). Specimens of *Mus musculus bactrianus* (Blyth), or a closely allied form, in the British Museum, differ from the Clontarf mice in that their paleness is due to a predominance of *white* tints, not of *yellow*. *Mus musculus flavescens* (Fischer) and *Mus musculus spretus* (Lataste), which according to Barrett-Hamilton probably intergrade, seem to come nearest to our race. I have never seen a typical example of either of these subspecies, but Southern European mice in the British Museum, which are probably referable to one or other of them or to something intermediate between them, are not half so light as my extreme cases. In fact, the lightest mice in my

series are as much lighter than any of the above subspecies as are the latter than the type!

Then it was suggested to me that, as in certain districts in the Eastern counties of Ireland a buff-coloured hare (*Lepus variabilis*) occurs, these mice might be a parallel case. In the first place, I have never seen a buff-coloured mouse from the mainland of Ireland, and, in the second place, the variation in the hares is apparently a "sporadic sport." Mr. Williams, the Dublin taxidermist, tells me that he has taken typical leverets and buff ones from the same uterus in hares sent to him for preservation. I have never seen any intergradation between the two colours in the hare. And even if the ultimate cause of the pale coloration in the mice was traced to the same circumstances (whatever they are) which cause the variation in the hare, we have still the fact before us, attested by a comparison of specimens from the mainland with those from the North Bull, that the mean colour of the North Bull specimens is infinitely paler than the mean on the mainland.

I think, however, that the very great variability of this new race is the strongest evidence of its being a recently evolved variety of *Mus musculus typicus*, which has not yet settled down into the comparative stability which usually characterizes a species.

When I came to enquire into the probable age of this colony, I was confronted with some very remarkable topographical evidence. Being convinced that these sandhills had a very recent origin, I referred to such old maps and charts of the Dublin Coast and County as were contained in the National Library of Ireland, and I owe a debt of gratitude to Mr. J. De W. Hinch for the valuable assistance he gave me in hunting up these records. A detailed account of the topography, past and present, of the North shore of Dublin Bay would be out of place here; and as my friend Mr. R. Lloyd Praeger is at present collecting evidence on this subject, with a view to investigating the origin of the flora of the North Bull, I will content myself with giving such facts as point to the date at which the island first appeared.

I regret that I cannot give the exact dimensions of the North Bull, it has increased considerably since the last edition of the Six-inch scale Ordnance map was published (1867). Mr. Praeger

hopes to have the island surveyed thoroughly before publishing his paper. I estimate its present length at about $2\frac{1}{2}$ miles.

The 1843 edition of the Six-inch Ordnance map figures the North Bull as a bank one mile and fifty chains long, the main island being only seventy-five chains long and separated by a patch of sand, covered at high water, from several small islands entered as " Islands in Raheny Parish." These were known as the " Bull Calves." The tidal channel is now dry, and supports the usual sand-loving plants that characterize the rest of the island, the smaller islands having united with the larger one.

The islands are figured similarly in the 1838–1868 sailing chart. In 1839 Beaumont, in his " Report upon a Design for the Improvement and Deepening of Dublin Harbour," speaks of the " Young Bull Calves " forming seaward of the old one.

Nimmo, in his 1823 map, figures a " sand-bank " one mile and thirty chains long, which is probably the island. He gives no details.

In Taylor's two maps, 1816 and 1819, the island is figured about $\frac{1}{5}$ mile long according to the scale.

Dawson's map, 1809, is a small map in which the island is figured as a small oval patch of land a little under $\frac{1}{2}$ mile long.

The disagreement between these early records perhaps speaks more for the inaccuracy of the maps than for the variability in relation of land and sea.

In 1805, in the " Report on the Improvements of Dublin Harbour by the Directors General of Inland Navigation " (Tidal Harbours Commission), there occurs the statement, " Since the building of the South Pier [about 1790] . . . . a considerable strip of the North Bull remains dry at high-water, and has on it a growth of marine plants."

The first map that figures this island is Cowans, 1800, where it is delineated as a small dry area on the submerged sand-bank.

Bligh's map, of the same date (in Warburton's ' History of the City of Dublin,' 1818), figures it as a quarter of a mile long. In the Dublin Harbour Improvement Commission (1800–1801), a letter is published from Richard Broughton to William Gregory, dated from the Ballast Office. Broughton refers to " the dry part of the North Bull ; " and further on he says : " The North Bull has increased very much both in extent and in height during the progress of the works on the South side, and more especially since their completion." (This refers to the building

of the South wall from the Pigeon-house to Poolbeg, which took place about 1790.)

Rocque's map, revised by Bernard Scale (1773), is a very careful and elaborate chart of the environs of Dublin. The North Bull Island is not figured, and certainly would have been if it existed, as the map goes into very great detail. Though the South wall is not yet built, the Pigeon-house and Poolbeg are connected by a row of stakes, which Haliday informs us ('Scandinavian Kingdom of Dublin,' pp. 235–236) were put there in 1717. It is needless to add that none of the many maps before this date that I have examined, going as far back as 1610, show any land, though the submerged bank is generally figured, and in some stated to be exposed at low tide. On the other hand, Dalkey Island and "Clontarf Island" (now, I believe, part of the mainland) are figured in most of them.

McKenzie's chart, 1775, does not bear a figure of the island.

Evidently between 1775 and 1800 the island first arose, and unfortunately between these two dates I cannot find any maps.

If the South wall was not built until 1790, it is probable that the island (if it existed before that date) was too small to support a colony of mice until the wall was finished; especially when we consider Broughton's statement in 1810, when the island was only $\frac{1}{4}$ mile long. These data allow us about 100 years for the evolution of the pale race, with a maximum limit of 120 years; and certainly, when one considers the exceptional circumstances, one cannot but think that a century or less would be more than sufficient to produce the form with which we are dealing.

A very interesting observation, which emphasizes the importance of Isolation in intensifying the effect of Natural Selection, has recently been recorded by Kane (3). He discovered, on a small island off the South-west coast of Ireland, a melanic race of the Geometer *Camptogramma bilineata*, which he names var. *isolata*; and he holds that this melanic form owes its existence to the weeding-out of the light ones by the Gulls, Pipits, and Bats that frequent the island, and that the darker ones, harmonizing with the colour of the rocks, escape more readily. On the adjoining mainland, as well as upon other parts of the coast where the rocks are of a dark colour, more or less melanic forms occur, but along with the type; but on this particular island the type is not to be found.

I do not myself know any case of the kind where a protective

adaptation can be pointed to in which we have *time data*, in which we can fix the maximum possible age of the variety; but very probably the dark Lepidoptera of the great Factory districts of England present such a case, and owe their existence to the smoky surroundings.

For an excellent summary of records of this kind in Insects, see Carpenter (4).

The study of such cases is a most fascinating one, as, owing to the limited number of factors at work, we may be able to trace, step by step, the causes and their modifying effects upon the species, and so to clear up many points as to the details of the process of elimination known as Natural Selection.

Papers referred to.

(1) Thomas, O.—"On a Wild living Mouse of the *Mus musculus* group in Portugal." Zoologist, 3rd ser. vol. xx. p. 137, 1896.

(2) Barrett-Hamilton, G. E. H.—"On Wild Forms or Subspecies of *Mus musculus*." Zoologist, 3rd ser. vol. xx. p. 178, 1896.

(3) Kane, W. F. de V.—"Observations on the Development of Melanism in *Camptogramma bilineata*." (Report to the Fauna and Flora Committee of the Royal Irish Academy.) Irish Naturalist, 1896, vol. v. p. 74.

(4) Carpenter, G. H.—"Colour Changes in Insects." Natural Science, vol. ii. p. 287, 1892.

EXPLANATION OF PLATE 30.

Varieties of *Mus musculus.*

The dark individual on the right-hand side is No. 4 in table (p. 466), the individual on the left is No. 27; that in the centre No. 30.

On the Larval Hyobranchial Skeleton of the Anurous Batrachians, with Special Reference to the Axial Parts. By W. G. Ridewood, D.Sc., F.L.S., F.Z.S., Lecturer on Biology at St. Mary's Hospital Medical School, London.

[Read 20th January, 1898.]

(Plate 31.)

Introduction.

The observations recorded in the following pages were made with the especial object of ascertaining whether the peculiarities of the larval hyobranchial skeleton of *Alytes* are common to all the genera of the family Discoglossidæ, and whether they occur in any genera not belonging to this family. The peculiarities in question consist in the presence of an anterior copula, and the complete separation of the hypobranchial plates by the posterior copula, which thus extends back to the laryngeal sinus, as already fully described in a communication recently presented to the Zoological Society, and appearing shortly in the 'Proceedings.'

Tadpoles of twenty-one species were examined, belonging to nineteen genera; and for all of the specimens I am indebted to Mr. G. A. Boulenger, F.R.S., whom I have always found most ready and anxious to encourage morphological enquiries of this kind, and to whom my thanks are hereby gratefully tendered. Considering how few of the species of Anura are known in their larval stages, the following list will be admitted to be very complete and representative.

The three numbers of the formula appended to each name stand respectively for the distance in millimetres from the snout to the root of the tail, the length of the tail, and the length of the hind limb. No measurement is given of the fore limb, because, in order to make the comparison between the different species as perfect as possible, the tadpoles were all selected at that stage in which the larval hyobranchial skeleton is most complete and most characteristic. This stage is recognized externally by the small size of the hind limbs, and by the fact that the fore limbs are not yet extruded through the atrial wall.

Ranidæ.			
Rana esculenta.	18.	24.	6.
Rana temporaria.	12.	22.	4.
Rana Whiteheadi.	10.	15.	2.
Oxyglossus lævis.	11.	29.	8.
Rhacophorus leucomystax.	16.	26.	10.
Phyllobates trinitatis.	5.	8.	0.
Engystomatidæ.			
Microhyla ornata.	6.	9.	2.
Cystignathidæ.			
Pseudis paradoxa.	41.	82.	28.
Telmatobius marmoratus.	35.	45.	7.
Chiroleptes platycephalus.	25.	34.	5.
Calyptocephalus Gayi.	41.	54.	9.
Bufonidæ.			
Bufo vulgaris.	12.	17.	3.
Hylidæ.			
Hyla arborea.	12.	22.	8.
Pelobatidæ.			
Pelodytes punctatus.	13.	16.	1.
Pelobates fuscus.	35.	60.	16.
Leptobrachium Hasselti.	24.	27.	9.
Discoglossidæ.			
Discoglossus pictus.	8.	11.	1.
Alytes obstetricans.	20.	35.	4.
Bombinator igneus.	16.	20.	6.
Dactylethridæ.			
Xenopus lævis.	25.	35.	6.
Pipidæ.			
Pipa americana.	10.	12.	4.

General Part.

The results of the investigation may be summarised in the following words:—The two fundamental peculiarities of the larval hyobranchial skeleton of *Alytes* above specified are found in the tadpoles of *Bombinator* and *Discoglossus*, but not in any of the other genera examined. This discovery is a lasting tribute to the perspicacity and intuition of the late Prof. Cope, who first brought together in taxonomic relationship the genera *Alytes*, *Discoglossus*, and *Bombinator*, which had previously been relegated

to three distinct families. Without entering into a discussion of the question whether the larval stages of Anura represent a true recapitulation of ancestral evolution, the similarity in the structure of the larval hyobranchial skeleton in these genera can, I think, be safely taken to indicate close genetic relationship.

The position of the anterior copula of the Discoglossidæ is in almost all the other forms examined occupied by loose connective tissue, the middle or hinder part of which is firmer and has the form of a transverse ligamentous band (fig. 2, *l*) connecting the ceratohyals. Gaupp, in his description of *Rana* tadpoles (**4.** p. 404), alludes to this band as being partially cartilaginous. Although I have failed to recognize anything approaching the structure of cartilage in the ligament, I fully concur with this author in regarding it as the morphological equivalent of the anterior copula of *Alytes*. I have not succeeded in finding the band in either *Pelodytes*, *Xenopus*, or *Pipa*.

Considerable diversity of form is observable in the shape of the second or posterior copula, and the proportion which it bears to the surrounding parts. It is usually longer than broad, but is broader than long in *Chiroleptes* (fig. 7, *cp.*) and *Telmatobius*. It is large in *Pelobates* (fig. 8), *Leptobrachium* (fig. 4), and the Discoglossidæ (fig. 1), but small in *Chiroleptes* (fig. 7) and *Phyllobates*.

Except in the Discoglossidæ, where the posterior copula extends back to the laryngeal sinus, the spaces at the right and left sides of the copula vary directly in size with the copula itself, being largest in *Pelobates* (fig. 8, *s*) and practically absent in *Phyllobates*. The hypobranchial plates are very variable in shape, the variability depending chiefly on the obliquity of their anterior edges and the length of their internal or mesial margins. These relations are themselves dependent on the proportionate size of the posterior copula. Thus, in *Chiroleptes* (fig. 7), the antero-lateral edges of the hypobranchial cartilages are very oblique and the median symphysis long, the copula being small and the lateral spaces small. The opposite extreme is exemplified by *Pelobates* (fig. 8), in which the anterior margin of the hypobranchial plate is strictly transverse and the symphysis short, these features being correlated with the large size of the copula and of its lateral spaces. *Hyla*, *Bufo*, and *Rana* (fig. 2) occupy intermediate positions between these extremes.

In early tadpoles, which alone are now under consideration, the posterior margin of the hypobranchial cartilage is but slightly indented by the laryngeal sinus, for the sides of this are bounded mainly by the spicula of the fourth branchial bar. This is absolutely the case in *Leptobrachium* (fig. 4, *ls.*), but the generalization does not hold good for the Discoglossidæ, and is only partially applicable to such genera as *Pseudis* (fig. 5) and *Rhacophorus*. In *Oxyglossus*, where there are no spicula, the laryngeal sinus is merely a notch at the back of the hypobranchial plate (fig. 6, *ls.*). The distinctness of the fourth spicula from the hypobranchial plates is most clear in *Leptobrachium* (fig. 4, $sp.^4$), in which these cartilages are very large; they are but feebly differentiated in *Pseudis* (fig. 5). It is of some interest to note that the first ceratobranchial is fused with the cartilage of the hypobranchial plate in all the forms examined except *Alytes*, *Bombinator* * (fig. 1, $cb.^1$), and *Discoglossus* (in which genera the union is effected by connective tissue), because in *Pelodytes* the basal portion of the bar persists as the processus posterolateralis of the adult hyoid (**12**. p. 590), whereas in *Alytes* the whole of the ceratobranchial skeleton is ultimately resorbed.

Microhyla, *Xenopus*, and *Pipa* are too exceptional to come within the scope of the foregoing generalizations, and these genera are, therefore, treated of only in the succeeding "Special Part."

The results of the present investigation cannot be said to have solved the problem of the morphological value of the hyobranchial copulæ of the Anuran larva. The most natural inferences to be drawn from the arrangement of the parts of the hyobranchial skeleton of the Discoglossidæ are that the anterior copula is the equivalent of the basihyal of the fish, and that the posterior copula is a basibranchial. But in such forms as *Rana* and *Pelobates* the single copula present is situated quite anteriorly to the branchial part of the skeleton; and although this fact does not prevent it still being regarded as a basibranchial (seeing that in *Notidanus* the basibranchial is situated anteriorly to the hypobranchial elements of the arch),

* This relation in *Bombinator* has already been pointed out by Götte (**5**. p. 679).

yet the deduction is unsatisfactory and inconclusive. That the single copula of the Ranid type of skeleton is the exact, or partial, equivalent of the posterior copula of the Discoglossid type is, I think, beyond question, in view of its close proximity to the pars reuniens, which latter is certainly homologous in the two cases.

The single copula of the Ranid type has been called the "basihyal" by Dugès (**3**) and the "basihyoid" by Schulze (**14**)*, while Parker (**8**) chose to name it the "basibranchial." But then Parker's nomenclature was seriously influenced by his regarding the pars reuniens as an essential constituent of the hyobranchial skeleton and his calling it, in consequence, the "basihyal" †.

The second basibranchial which Parker has described in *Calyptocephalus* and *Cyclorhamphus* cannot be allowed to carry much weight in the discussion. It is probably to be explained as an exceptional duplication of the single copula, if not as an error of observation, or as an accidental tearing of the cartilage in the dissection of the specimen (see p. 482).

Special Part.

Ranidæ.

The structure of the hyobranchial skeleton of the early larva of *Rana* has recently been so ably investigated by Gaupp (**4**), that I abstain from a full description of the parts. A figure is here given (fig. 2), not in order to illustrate any new features, but for the convenience of the reader of the following notes on those genera which are not figured but are compared as regards the structure of their larval hyobranchial skeleton with the common frog. The thoroughness of Gaupp's paper renders an historical summary also unnecessary, the earlier figures by Cuvier (**2**), Saint-Ange (**13**), Rathke (**9**), Reichert (**10**), Parker (**7** & **8**), Stöhr (**15**), and Naue (**6**) being criticised and effectually disposed of in this work. The only point on which I venture to differ

* Schulze does not include the pars reuniens in his "basihyoid" as Gaupp leads one to infer (**4.** p. 412). He calls it "eine querfaserige Bandmasse" (**14.** p. 9), corresponding with the "basihyal" of Parker, and he figures it quite distinct from his cartilaginous "basihyoid" (**14.** Taf. 1. fig. 5).

† The exceptional chondrification of the pars reuniens in *Microhyla* (p. 481) does not, in my opinion, entitle it to rank as a morphological unit in the larval hyobranchial skeleton, any more than a sesamoid chondrification in a tendon is to be considered as a morphological constituent of the limb-skeleton.

from Dr. Gaupp is in his interpretation of "connective tissue," a matter to which I have already referred in an earlier communication (**11**. p. 97). Dr. Gaupp's figures of the early hyobranchial skeleton show all the constituent cartilages perfectly continuous, whereas in specimens dissected under spirit there can be seen a distinct differentiation of tissue at the line of junction of certain parts, along the hypobranchial symphysis for instance. This tissue is yellowish and opaque, and frequently stands out in strong contrast with the hyaline cartilages on either side of it, and this it is which has been called "fibrous tissue," "connective tissue," "Bindegewebe," etc. by various authors. When, however, sections are cut and, after staining and clarifying, are examined under the microscope, all this differentiation disappears. The cells of the "connective tissue" are slightly smaller and are more closely packed than those of the hyaline cartilage, but the two tissues graduate so insensibly into one another that histological differentiation is denied by those who adopt this method of investigation only. The difference of opinion between Gaupp (**4**. p. 415) and Naue (**6**. p. 139) as to the mode of connection between the last three branchial bars and the hypobranchial plate, is solely dependent on this question. There is certainly a difference between the mode of attachment of the first and the following arches, for, when seen under a lens, the first ceratobranchial is so continuous with the hypobranchial plate that no line of junction can be discerned, but in the case of the other three there is a faint yellow line which marks the limit of the hypobranchial cartilage. This line indicates the position of the "connective tissue," and by declining to admit the existence of this tissue Gaupp is forced to deny the difference in the distinctness of the limits of the proximal ends of the first and the remaining three branchial arches, a difference which in such a Ranid as *Oxyglossus* is so marked as to be visible to the naked eye.

No difference whatever is to be seen between the hyobranchial skeletons of early larvæ of *Rana esculenta* and *Rana temporaria* (fig. 2). The tadpoles are so much alike that this perhaps is not surprising. But some palpable difference was to be expected in the third species examined, for in *Rana Whiteheadi*, as in the genus *Micrixalus*, the tadpole is provided with a large suctorial disc, extending nearly the full width of the body, and occupying about half the distance between the mouth and cloaca. This

sucker, which in all probability represents the persistent and greatly enlarged ventral sucker which in our common frog is characteristic of the very early larvæ breathing by external gills, enables the tadpoles to adhere to rocks and stones in the mountain torrents in which they live. It gives a most singular appearance to the tadpole, but appears not to affect the internal organs. The hyobranchial skeleton, at all events, differs from that of *R. temporaria* only in that the internal or mesial parts of the ceratohyals are more expanded, and that the hypobranchial symphysis is shorter.

Rhacophorus differs from *Rana* only in the shallowness of the hyoglossal sinus, and in the fact that the hyobranchial plates are longer than broad, the reverse obtaining in the frog. The early tadpole of *Oxyglossus* possesses a hyobranchial skeleton which is remarkable for the relatively great size of the hyoid arch and the small development of the branchial system. The width of the branchial part of the skeleton is much less than that across the hyoid even at this early stage (see fig. 6). Filling the hyoglossal sinus and projecting some little distance in front of it, is a dense fibrous mass in which the normal transverse ligament is not clearly differentiated. The branchial bars are short, thin, and straight, and have no spicula. The first ceratobranchial is confluent with the hypobranchial cartilage, while the other three are attached by means of a well-marked fibrous tissue. Since there are no fourth spicula, the laryngeal sinus is very shallow; but it probably deepens later by absorption of the hypobranchial cartilage. The spaces at the side of the copula are well defined and triangular in shape. The pars reuniens is but feebly developed, and the ceratohyals touch one another in the median line.

The specimen of *Phyllobates* examined was one taken from the back of the father, to whose skin the tadpoles adhere in time of danger. The hyobranchial skeleton differs from that of *Rana* chiefly in the greater relative size of the hypobranchial plates and the corresponding smallness of the copula. The symphysial line disappears in the posterior third, so that the two hypobranchial plates are fused here. The first ceratobranchial is confluent with the hypobranchial plate, while the other three adhere by fibrous tissue, as in *Rana*, *Oxyglossus*, *Rhacophorus*, and probably in many other genera. Spicula are present, but they are proportionately shorter and more stunted than in *Rana*.

In spite of the extreme minuteness of the whole hyobranchial skeleton, such features as the ligamentous band in the hyoglossal sinus and the space at the side of the copula can be easily made out by ordinary dissection.

Engystomatidæ.

The tadpoles examined were collected in Siam and presented to the Natural History Museum, London, by Mr. Stanley Flower, and were reported by him to be the offspring of *Microhyla ornata*. They bear a remarkable resemblance to the larvæ of *Xenopus* of the Cape, in shape, general transparency, and the silvery appearance of the abdomen.

The hyobranchial skeleton is most singular (fig. 3). The hypobranchial plates are fused across the median line, and have a thickened anterior margin which is fused with the hind end of the copula. The place where the pars reuniens normally occurs is occupied by a transverse bar of cartilage, fused at its extremities with the ceratohyals. The postero-internal parts of the ceratohyals are free, and overlap the anterior edge of the hypobranchial plate. The hyoglossal sinus is shallow, and the transverse ligamentous band is very distinct. The ceratobranchial skeleton has the form of a pair of great pouches perforated at the bottom by three slits, and in this respect, also, the tadpoles under consideration resemble *Xenopus*. The laryngeal sinus is narrow and deep, but owing to the fourth ceratobranchials being in contact with one another behind it, as in *Xenopus*, the larynx itself is situated very far back.

It would be interesting to ascertain what are the conditions of life which have evidently been instrumental in bringing about these external and these skeletal resemblances between two such remotely allied genera as *Microhyla* and *Xenopus*. That the two results have been arrived at independently is, I think, beyond question, for although the resemblances are so striking at first glance, the similarity does not extend into the smaller structural details.

Cystignathidæ.

Of the four genera examined, two (*Chiroleptes* and *Telmatobius*) resemble one another so exactly in the structure of their larval hyobranchial skeleton that one of them may be dismissed at once. *Pseudis* differs from these in several respects, notably

in the size of the space at the side of the copula, which is large in *Pseudis* (fig. 5, *s*) but extremely small in *Chiroleptes* (fig. 7). The copula itself is longer in *Pseudis*, and the pars reuniens is broader. Owing probably to the shortness of the copula in *Chiroleptes*, the hypobranchial symphysis is much longer in this genus than in *Pseudis*. The fourth pair of spicula are normal in the former, but are greatly expanded and fused with the third pair in *Pseudis*; a feature already alluded to and figured by Parker (8. p. 73, pl. 10. fig. 6, and pl. 11. fig. 4, *c. br.* 3–4), although in his figures the shape of the parts is not quite correct. In the earlier figure by Cuvier (2. pl. xxiv. fig. 22) this point is not evident.

Parker has also figured (8. pl. 17. fig. 4) the hyobranchial skeleton of a tadpole which, with some reserve, he identifies as *Cystignathus*. The figure, however, calls for no special comment. Two other genera of the Cystignathidæ were also examined by this author, and in both (*Calyptocephalus Gayi*, 8. pl. 22. fig. 5, and *Cyclorhamphus culeus*, pl. 22. fig. 9) a double basibranchial described and figured. Seeing how important from a morphological point of view the occurrence of two successive basibranchials would be, it is somewhat surprising that the author did not lay more stress upon the observation. Now the *Cyclorhamphus culeus* examined by Parker is a *Telmatobius* (probably *Telmatobius Jelskii*, see 1. p. 191); and since the double copula does not occur in the *T. marmoratus* examined by me, a shadow of suspicion naturally arises. To submit the matter to the final test, I applied to Prof. Lataste for permission to examine one of the tadpoles of *Calyptocephalus Gayi* from Chili, belonging to his private collection, and he most graciously responded. There is in Prof. Lataste's specimen no trace of a second copula behind the pars reuniens, but the whole hyobranchial skeleton is perfectly normal, and occupies a position midway between those of *Chiroleptes* and *Pseudis* in the proportions of the pars reuniens, copula, lateral spaces, and fourth spicula. It is evident, therefore, that no great weight can be attached to this observation of Parker's.

Bufonidæ.

The hyobranchial skeleton of *Bufo* does not differ greatly from that of *Rana*. The anterior edge of the hypobranchial cartilage is more oblique, and a different shape is in consequence given to

the triangular space at the side of the copula. The width of the copula is only one half that of the pars reuniens, whereas in *Rana* the two are nearly equal in breadth. The larynx is exceptionally far back, being nearly in a line with the posterior extremity of the fourth ceratobranchial. In no early Anuran tadpole does the larynx actually lie in the laryngeal sinus, for the latter name is anticipatory, and refers to a space which, in the adult, lodges the larynx; but in *Bufo* the larynx is farther removed from the sinus than is usual in larvæ of this stage.

Hylidæ.

In the proportions of the pars reuniens, the copula, and the spaces at the sides of the latter, the larval hyobranchial skeleton of *Hyla* approaches more closely to that of *Rana* than does that of *Bufo*. The first three pairs of spicula are a little longer than those of the frog, but the difference is slight. The line of demarcation between the hypobranchial cartilage and the fourth spiculum cannot be made out, the two cartilages being more continuous than in *Rana*.

The larval skeleton of *Nototrema* was examined by Parker, but not figured. It is described as being quite normal (**8.** p. 188). The meagre figure of *Hyla* by Stohr (**15.** Taf. iii. fig. 11) shows only the hypobranchial cartilages and the basal ends of the ceratobranchials confluent with them.

Pelobatidæ.

The three genera examined exhibit considerable uniformity of structure. The space at the side of the copula is large and triangular, the symphysial line between the hypobranchial plates is shorter than the antero-posterior diameter of the copula, and the ceratohyals are large in proportion to the branchial skeleton. The larval hyobranchial skeleton of *Pelobates* has already been figured by Dugès (**3.** Taf. xiii. fig. 75) and Schulze (**14.** Taf. i. fig. 5), and that of *Pelodytes* by myself (**12.** fig. 1).

The fibrous band which so commonly stretches across the hyoglossal sinus is clearly distinguishable in *Pelobates* and *Leptobrachium*; but on examining my former preparations of *Pelodytes*, and several new ones as well, I am still unable to detect it in this genus. The copula is considerably longer than broad in *Pelobates* (fig. 8, *cp.*) and *Leptobrachium* (fig. 4), but it is somewhat more hexagonal in *Pelodytes*. The pars reuniens in *Pelo-*

dytes is correspondingly long in an antero-posterior direction, while the outline of this fibrous mass is nearly square in *Pelobates* and *Leptobrachium*.

The lateral parts of the ceratohyals are exceptionally massive in *Leptobrachium*, and this genus is also remarkable in having the incipient laryngeal sinus bounded laterally, not by the hypobranchial cartilage tipped with the spiculum of the fourth branchial arch, but by the spicula alone (fig. 4, *ls.*). These latter are so largely developed as to simulate early and autogenous thyrohyals. In fact their exceptional proportions in this early stage may actually affect the later development of the thyrohyals. I have been unable to procure older larvæ of *Leptobrachium* to determine this point.

Discoglossidæ.

As already mentioned in the earlier part of this paper, there is a remarkable similarity in the structure of the larval hyobranchial apparatus in the three genera *Alytes*, *Bombinator*, and *Discoglossus*. The characters which they have in common, and which do not occur in any other Anuran larva examined, are:—the presence of an anterior copula in front of the pars reuniens, and the complete separation of the two hypobranchial plates by the large posterior copula situated behind the pars reuniens. I have already stated, in a paper presented to the Zoological Society in November 1897, that the credit of the discovery of the anterior copula of *Alytes* belongs to Gaupp (**4**. pp. 411–412). The figure which Götte has given of the larval hyobranchial skeleton of *Bombinator* (**5**. Taf. xviii. fig. 332) shows very well the extremely small size of the cleft between the third and fourth ceratobranchials, but the axial parts of the skeleton are rather indistinct. Three areas, probably representing the anterior and posterior copulæ with the fibrous pars reuniens between, can be distinguished, but no special notice is taken of the relations or the morphology of the parts. The earlier figures of *Bombinator* by Reichert (**10**. Taf. i. figs. 20 and 23) are so imperfect as to call for no detailed criticism.

In all three genera the transverse diameter of the anterior copula is greater than the longitudinal, and the copula is separated from the pars reuniens by a small space—quite minute in *Discoglossus*. The space between the antero-lateral border of

the second copula and the ceratohyal is very narrow in all three. Since a figure of the larval hyobranchial skeleton of *Alytes* is now appearing in the 'Proceedings' of the Zoological Society, and since the differences between *Discoglossus* and *Bombinator* are so slight, a figure of the hyobranchial skeleton of this last genus satisfies the requirements of the present communication (fig. 1).

Dactylethridæ and Pipidæ.

These two families may be shortly disposed of by referring the reader to my earlier remarks on the development of the hyobranchial skeleton of *Xenopus* and *Pipa* (**11**. pp. 91–111). It is impossible to say whether *Pipa* comes nearer to the Discoglossid or to the Ranid type of larval hyobranchial skeleton, for no copula can be distinguished, the whole cartilage being uniform and continuous throughout (**11**. pl. xi. fig. 4). No spicula are present, and the hyoglossal and laryngeal sinuses are, even in this earliest stage investigated, already deep. A re-examination, however, of my youngest specimens of *Xenopus* shows that the outline of the copula (**11**. pl. xi. fig. 1, *bh*) is more sharply defined than the figure would suggest, and that a long, narrow, faintly-outlined pars reuniens connects the anterior parts of the ceratohyals together and involves the thin end of the copula. There is nothing resembling an anterior copula, and the hyoglossal sinus is merely a small **V**-shaped notch. The hypobranchial part of the skeleton is reduced in size, and is wedged in between the copula and the great ceratobranchial pouches. It tapers to a point behind, far removed from the larynx, which occupies a very posterior position. The obvious conclusion to be drawn from the absence of a copula in front of the pars reuniens and the union of hypobranchial cartilages behind the posterior copula, is that the hyobranchial skeleton does not conform to that of the Discoglossid larvæ.

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EXPLANATION OF PLATE 31.

All the figures represent the hyobranchial skeleton of early tadpoles, the measurements of which are given on p. 475. Except in figs. 3 and 6 the ceratobranchials are shown only on one side of the figure, or are not shown at all. All figures exhibit the dorsal aspect; and the magnification is expressed by the usual symbols in the Plate.

Fig. 1. *Bombinator igneus.*
2. *Rana temporaria.*
3. *Microhyla ornata.*
4. *Leptobrachium Hasselti.*
5. *Pseudis paradoxa.*
6. *Oxyglossus lævis.*
7. *Chiroleptes platycephalus.*
8. *Pelobates fuscus.*

Reference Letters.

ca. Anterior copula (fig. 1).
cb.[1] First ceratobranchial.
ch. Ceratohyal.
cp. Posterior copula in fig. 1; the copula in figs. 2–8.
hbr. Hypobranchial plate.
l. Ligamentous band in the hyoglossal sinus.
ls. Laryngeal sinus.
pr. Pars reuniens.
s. Space at the side of the copula.
s.[1] Space between the anterior copula and the pars reuniens (fig. 1).
sp.[4] Spiculum of the fourth branchial arch.

The "Porus genitalis" in the *Myxinidæ*. By R. H. Burne, B.A., Anatomical Assistant in the Museum of the Royal College of Surgeons of England.*

[Read 20th January, 1898.]

(Plate 32.)

Since the days of Johannes Müller † no detailed investigation has been made into the coarse anatomy of the cloacal region of the Myxinoids; subsequent anatomists ‡ having for the most

* Communicated by Prof. G. B. Howes, Sec. Linn. Soc.

† Johannes Müller, "Untersuch. über die Eingeweide der Fische," Abhl. d. k. Akad. Wiss., Berlin, 1843, p. 113.

‡ Vogt & Pappenheim, "Organes de la génération des Vertébrés." Ann. Sci. Nat. sér. 4, xi. 1859, p. 345; W. Müller, "Urogenitalsystem des Amphioxus u. der Cyclostomen," Jena. Zeitschr. ix. 1875, p. 109.

part dealt with the related family of the Lampreys, or contented themselves with a summary of Müller's original description of *Myxine glutinosa*. An exception must be made, however, in favour of Ewart *, for, at the end of a paper on the genital pores and surrounding parts of the Lamprey, he devotes a few lines of original description to the same organs in *Myxine*. Yet, on the whole, our present information upon this subject is so scanty and, as will appear later, inaccurate, that I venture to put forward the following brief description and drawings of the anatomy of the cloacal region in *Myxine glutinosa* and *Bdellostoma cirrhatum*, in the hope that they may form an appendix to the excellent description given by Ewart of these parts in the Lamprey.

According to Ewart, "the intestine of the Lamprey is a straight tube which lies free in the abdominal cavity, except near its termination, where several fine bands—the remains of the mesentery—fix it to the under surface of the notochord." The body-cavity, after the intestine has reached the ventral body-wall on its way to the anus, is continued on either side in the form of a blunt cone, near the apex of which a small aperture leads into a pyriform chamber (the uro-genital sinus). The base of the uro-genital sinus is in open connection with the ureters, and the apex projects freely into an integumentary pit, into which it opens close behind the anus. Thus we have a pair of internal "pori genitales" opening on either side from the body-cavity into a uro-genital sinus, and a single median external pore opening from the latter into the cloaca. Such appear to be the essential features of Ewart's description; but before leaving the Lamprey there are two minor points upon which I would comment. Ewart makes a great feature of the blunt ending of the body-cavity and its backward extension (1 line) beyond the "genital pores," and infers therefrom an error of observation on the part of Müller, who speaks of the "genital pores" having the form of a pair of tubes, one on either side of the rectum, that open at their ends into the uro-genital sinus. An examination of the cloacal region in the River Lamprey suggested to me that the discrepancy between these two accounts might very possibly be due to the description of a different species in either case. Müller, we know, examined both the Sea and River Lamprey

* J. C. Ewart, "Note on the Abdominal Pores and Uro-genital Sinus in the Lamprey," Journ. Anat. and Phys. x., 1876, p. 493.

(*Petromyzon marinus* and *fluviatilis*); but, as his description applies to the river form alone, one cannot avoid the suspicion that, although he may have cursorily examined *P. marinus*, his real observations were confined to *P. fluviatilis*. Ewart does not in his paper mention the species of Lamprey used, but through the kindness of my friend Professor Howes, F.R.S., I have ascertained that it was *P. marinus*; a conclusion to which I had been led by a comparison of his description with a dissection of that species. In this way the conflicting statements appear to admit of explanation. Then, again, with reference to the opening of the ureters into the uro-genital sinus, it should perhaps be more emphatically mentioned that the passage of the one into the other is gradual and imperceptible; the ureters, in fact, meet in the mid-line, coalesce and dilate to form the sinus; there is no papilla or any other mark to show where the one ends and the other begins.

As concerns *Myxine glutinosa*, in which the "pori genitales" are described as essentially similar to those of the Lamprey, I find a very different state of affairs, of which the following is a description (fig. 1) based upon the dissection of six specimens, checked by the examination of a series of transverse sections through a seventh *.

When the creature is placed upon its back, the mouth of the cloaca has the appearance of a narrow longitudinal slit some 10 mm. long, bordered by somewhat protuberant lips. The slit leads into a small chamber (fig. 1, *cl.*) flattened from side to side, and having roughly the form of an isosceles triangle placed in such a position that one of its sides corresponds to the cloacal slit and its short base to the anterior wall of the cloacal chamber. In the walls of this chamber there are four openings: two, of large size, in the anterior wall placed vertically one above the other, the anus below and the genital pore above (fig. 1, *an. p.g.*); and a smaller pair belonging to the ureters, situated close side by side on a papilla halfway along the dorsal wall (fig. 1, *ur.o.*). The dorsal and lateral walls of the cloacal chamber are raised into several longitudinal ridges that can be separated into a lower series continuous with the rectal rugæ, and an upper originating from the margin of the pore. Between these two

* These specimens of *Myxine glutinosa* were obtained from the Bergen Museum for the Royal College of Surgeons, some preserved in spirit, some in formalin.

series the lateral parts of the dorsal lip of the anus extend backwards some little distance, forming a short but prominent lateral ridge; and in the dorsal mid-line another prominent ridge is formed by the inpushing of the ureters on their way to open on the urinary papilla. Behind the papilla the ridge is continued on, though diminished in size, to the posterior limit of the cloaca.

The intestine in *Myxine* is suspended by a dorsal mesentery, continuous to within some 6 or 7 mm. of the posterior extremity of the body-cavity (Pl. 32. fig. 1, *mes.*); on its ventral aspect it is free, but at a point 10 mm. in front of the anus it meets the ventral body-wall, within which it becomes gradually embedded as it bends downward towards the anus: in consequence the posterior end of the body-cavity becomes rapidly constricted and confined more and more to the dorsal surface of the intestine, until at a point directly above the anus it is entirely dorsal in position, and opens by a single pore of 1·2 mm. breadth into the cloaca (fig. 1, *p.g.*). The peritoneal lining of the body-cavity becomes thicker and closer in texture as the pore is approached, till round the actual orifice of the pore it forms a stout band (fig. 1, *fb.bd.*) of white fibrous tissue extremely rich in small round or pointed cells. Just before the anal opening is reached a gland (fig. 1, *sl.gl.*) makes its appearance in its upper lip, and as we pass backward gradually extends upward on either side into the lateral walls of the genital pore, and finally forms a complete circle by meeting in the dorsal mid-line. The chief part of the gland is situated in the dorsal lip of the anus and lateral walls of the pore, and is formed of several lobes or divisions separated one from the other by strands of connective tissue, from which yet finer strands are given off that subdivide the lobes into smaller compartments or lobules. Each lobule contains one or more spider-cells, and now and again one of the peculiar "thread-cells" characteristic of the lateral slime-glands, though the number of these is comparatively limited. The lobes have the form of flattened cones lying side by side with their apices directed forward; the bases of the cones are open, and so placed that they form a semicircle of openings round the ventral and lateral parts of the posterior margin of the pore; the extension of the gland upon the dorsal wall of the pore has the form of open glandular grooves. The openings of the gland correspond to the grooves between the upper series of cloacal ridges mentioned previously,

while the ridges themselves are formed by a backward extension of the interlobular connective tissue. In other words, the grooves between the upper series of cloacal ridges have at their anterior ends the structure of the lateral slime-glands, and are prolonged as glandular conical pockets for some distance into the lateral and ventral walls of the pore. I have gone at some length into the structure of this gland, as I believe that hitherto the features peculiar to the lateral slime-glands have been found there, and nowhere else*.

The ureters (fig. 1, *ur.*) run one on either side of the dorsal mid-line, outside the peritoneum; towards the posterior end of the body-cavity they approach each other, then run backward close side by side upon the dorsal wall of the cloaca, and finally open into it by a pair of slit-like openings upon the urinary papilla (fig. 1, *ur.o.*).

In addition to *Myxine glutinosa* I have been able to make a dissection of *Bdellostoma cirrhatum*, and find that in this genus the "porus genitalis" differs in several points from that of *Myxine*. In the first place the pore (fig. 2, *p.g.*) is very large, extending for 6 mm. on either side of the middle line; it is also situated considerably farther forward than in *Myxine*, lying 14 mm. in front of the anus instead of directly above it. The forward position of the pore is accompanied by a corresponding forward extension of the cloacal chamber upon the dorsal surface of the rectum, and by the obliteration of the unpaired portion of the body-cavity that in *Myxine* lies between the posterior edge of the dorsal mesentery and the pore. Thus we are practically dealing with a pair of genital pores, each 6 mm. broad, lying close side by side upon the dorsal surface of the rectum and separated one from the other by the edge of the mesentery. At first sight, one is sorely tempted to regard this condition as intermediate between the paired lateral pores of the Lamprey and the single median pore of *Myxine*—a step in the formation of a dorsal pore by the coalescence of a pair of lateral pores; but this is probably not the case. For when we notice that the body-cavity of *Bdellostoma* does not extend backward beyond the position of the edge of the mesentery in *Myxine*, and that the end of the rectum covered in *Myxine* by peritoneum is in *Bdellostoma* clothed by a highly specialized extension of the cloacal epi-

* Bloomfield, "The Thread-cells and Epidermis of *Myxine*," Quart. Journ. Micr. Sci. xxii., 1882, p. 355.

thelium, while the rest of the cloaca with the anal and ureteric openings has much the same form and proportions as in *Myxine*, we must consider that this region in *Bdellostoma* is in a less simple and generalized condition than in *Myxine*, and that the division of the pore is most likely a secondary modification brought about by its apposition to the edge of the mesentery in consequence of the forward extension of the cloaca,—in fact an incident in the history of the pore after, and not before, its assumption of the single condition; so that although, to all intents and purposes, *Bdellostoma* has two genital pores, morphologically it, like *Myxine*, has but one. The peritoneal thickening that surrounds the pore is well-developed and seems, so far as the imperfect preservation o the material at my disposal shows, to be more fibrous and less cellular than in *Myxine*; it is thicker above and below than at the extreme lateral points, giving to the pore in its normal state the form of a long narrow slit with its dorsal and ventral surfaces closely apposed.

The portion of the cloaca between pore and anus (fig. 2, *cl.ex.*) is raised into a number of longitudinal laminæ arranged somewhat as follows:—In the dorsal mid-line there is a very conspicuous single lamina, followed on either side after a small smooth space by a group of about 12 laminæ of slightly smaller size, arranged close side by side, parallel one to the other; upon the ventral wall the laminæ have a similar arrangement, though none of them are quite so strongly marked. The space between the laminæ is filled with a quantity of sticky slime, which is seen under the microscope to correspond to the secretion of the lateral slime-glands. The failure of transverse sections to show any communication between this part of the cloaca and the lateral slime-glands, in addition to the presence of a slime-gland round the abdominal pore in *Myxine*, would lead one to expect that the laminæ are the seat of the secretion of the slime. Unfortunately the state of preservation prevents my saying anything very definite upon their histology; but the following points seem fairly clear and, so far as they go, support the notion that this region of the cloaca is a slime-gland. The laminæ are supported by a central sheet of connective tissue, from which are given off subsidiary branches that now and again anastomose with one another; the connective-tissue support is clothed by a deep epithelium, often broken up by finer anastomosing strands of connective tissue into round glandular-looking follicles: whether

some of these are in reality spider-cells I cannot definitely say, but thread-cells can be certainly seen here and there buried in the tissues.

From the foregoing descriptions, the great difference that exists between the Myxinoids and their nearest relatives—the Lampreys—with regard to their "pori genitales" has, I trust, been made sufficiently clear. The explanation of the difference is most likely bound up with the function performed by the pores, for in the Marsipobranchii their chief duty is important enough to account for any suitable modification of their structure, since they form the sole passage by which the generative products can reach the exterior. The "genital pores" in the Lamprey, in which the reproductive elements are small (the ova being about the size of a small shot), are, as we have seen, paired and of such size (·5 mm. in *P. fluviatilis* *) that, under pressure of the ripe ova in the body-cavity, they expand enough to allow of their passage †. On the other hand, the Myxinoids possess ova few in number but large in size (a fairly ripe ovum of *Myxine* being a spindle-shaped body 19 mm. in length by 7 mm. in diameter, and that of *Bdellostoma* 31 mm. in length and 9·5 mm. in diameter). For the passage of such an ovum, pores similar to those of the River Lamprey would be clearly too small and certain to suffer extensive rupture if the ovum succeeded in making its exit. But instead of such pores, we find in *Myxine* a single median pore of very considerable size, and in *Bdellostoma* an enormous pore divided into two, in both cases admirably suited for the passage of a large-sized egg. For not only is the aperture large, but, to guard against any possible danger of rupture, it is encircled by a stout band of connective tissue, uncalled for in the case of the Lamprey with smaller eggs. What the special use of the slime secreted round the edge of the pore in *Myxine*, and more copiously in the anterior cloacal prolongation of *Bdellostoma*, may be, it is not very easy to say. It may of course have a certain lubricating effect in oviposition; but to judge from the

* These remarks do not apply to the Sea Lamprey, in which the pores are larger than the size of the egg would appear to warrant. Ewart speaks of their diameter as nearly 2 lines in the species examined by him (*P. marinus*), and in a specimen in the Royal College of Surgeons Museum I find them fully that size.

† Gulliver (Proc. Zool. Soc. 1870, p. 848) found 51,220 ovarian eggs in *P. fluviatilis*, and gives $\frac{1}{60}$ in. as their diameter; in *P. Planeri* the diameter was about $\frac{1}{40}$ in.

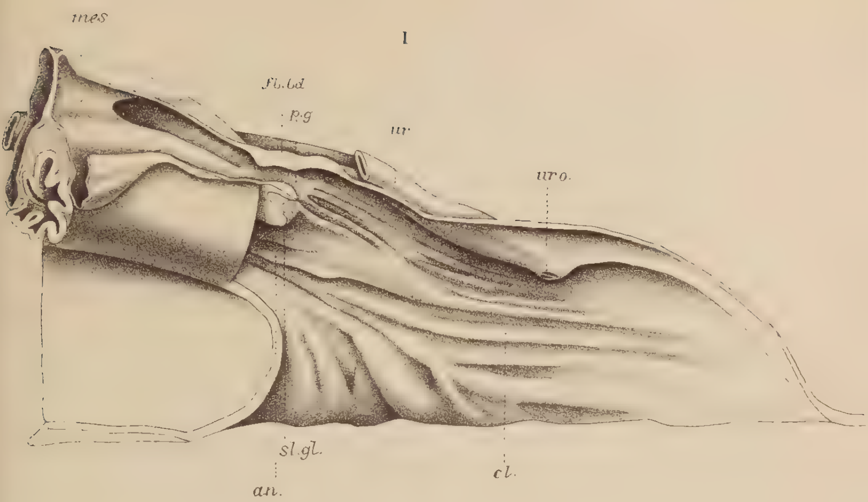
direct relation that exists between the quantity of slime secreted and the size of the pore, it looks as if it might answer somewhat the same purpose as the wax secreted in our own external auditory meatus, by preventing the intrusion of foreign matter, animate or inanimate, into the body-cavity, a danger to which the possessor of two contiguous pores, each 6 mm. broad, would seem to be especially exposed.

It will have been observed that the main difference between the Lampreys and Myxinoids lies in the absence in the latter of the direct communication between the "porus genitalis" and the uro-genital sinus that forms so characteristic a feature in the former. The apparent absence of the uro-genital sinus in the Myxinoids is, I am aware, generally explained by regarding the upper part of the cloacal chamber as its representative; but the following features seem to indicate that its absence is not apparent, but real. Although there seem to have been some contradictory statements made * in regard to the development of the cloaca in the Lamprey, yet the following account, taken from a recent detailed paper on the transformation of Ammocœte to Lamprey †, may probably be considered as fairly representing the truth:—The segmental ducts open originally into the posterior region of the gut, and then, during the passage of the Ammocœte into the Lamprey, their posterior ends fuse to form a common chamber into which, as it gradually separates from the gut and acquires an opening into an integumentary cloacal pit, the hitherto blind posterior prolongations of the body-cavity open, forming the "genital pores." So that in the adult we can sharply distinguish an uro-genital sinus, formed by the fusion of the segmental ducts, from an integumentary cloacal pit into which it opens. Now in the adult Myxinoid the ureters do not imperceptibly pass into the cloacal chamber, as they do into the uro-genital sinus of the Lamprey, but open upon a raised papilla; upon the margin of the ureteric opening, the epithelium changes its character—inside it is similar to that lining the rest of the ureter, outside it is epidermic. The whole cloacal chamber, both in *Myxine* and *Bdellostoma*, is lined by epidermis. For these reasons I am inclined to consider that the uro-genital sinus of the

* Ayers, "Untersuchungen über Pori abdominales," Morph. Jahrb. x. (1885) p. 346.

† Bujor, "Métamorphose de l'*Ammocœtes branchialis* en *Petromyzon Planeri*," Rev. Biol. Nord France, iii. (1891) p. 484.

1



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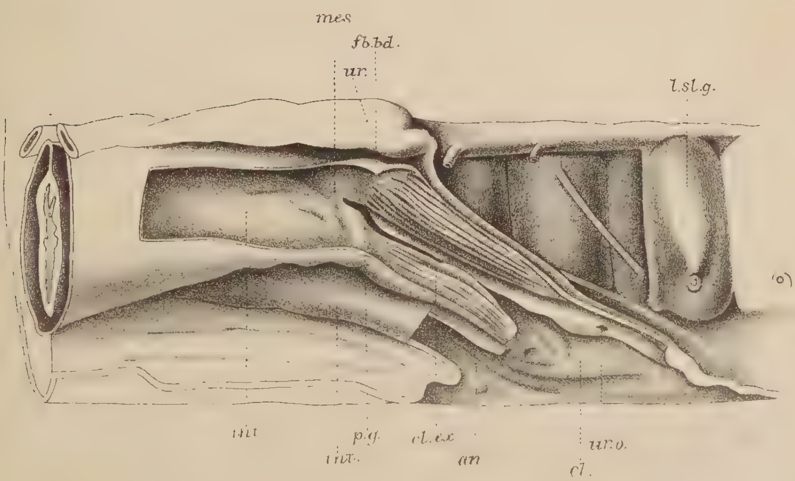


R.H.B. del.
Parker & Percy lith.

Geo. West & Sons imp.

PORUS GENITALIS IN THE MYXINIDÆ.

Lampreys is absent in the Myxinoids, and that in the latter the anus, "porus genitalis," and ureters open into an integumentary cloacal chamber, similar to the cloacal chamber common to anus and uro-genital sinus in the Lamprey.

EXPLANATION OF PLATE 32.

Fig. 1. Cloacal region of *Myxine glutinosa* seen from the left side, ×5. The left wall of the cloaca and body-cavity has been removed. *sl.gl.* Slime-gland in upper lip of anus.

Fig. 2. Cloacal region of *Bdellostoma cirrhatum* dissected in the same way as fig. 1, ×2. The left half of the pore only is seen.

Reference Letters.

an. Anus. *cl.* Cloaca. *cl.ex.* Extension of cloaca. *fb.bd.* Fibrous band surrounding abdominal pore. *int.* Intestine buried in body-wall. *int'.* Intestine covered by peritoneum. *l.sl.g.* Lateral slime-glands. *p.g.* Porus genitalis. *ur.* Ureter. *ur.o.* Urinary papilla. *mes.* Dorsal mesentery.

On the Affinities of the Madreporarian Genus *Alveopora* with the Palæozoic *Favositidæ*, together with a brief Sketch of some of the Evolutionary Stages of the Madreporarian Skeleton. By H. M. Bernard, M.A. Cantab., F.L.S.

[Read 16th December, 1897.]

(Plate 33.)

The genus *Alveopora* was founded by Quoy and Gaimard * for a coral from New Ireland collected during the voyage of the 'Astrolabe.' The original description given by these authors is intelligible and accurate so far as it goes, but the figures appear to have been drawn from memory, and certainly do not represent any known species of *Alveopora*.

The *Madrepora retepora* of Ellis and Solander, Forskål's *Madrepora dædalea*, the coral so beautifully figured by Savigny in his 'Description de l'Égypte' (tab. iii. fig. 4), and certain of Lamarck's types were soon recognized as specific forms of this new genus.

In 1848 Dana † boldly claimed the genus as belonging to the Palæozoic Favositidæ, which he classed as the second of his three

* Voyage de l'Astrolabe (Zoologie), iv. 1833, p. 240.

† 'Zoophytes,' p. 117.

families comprising the Madreporacea, this tribe being characterized by "twelve tentacles (rarely more) in one series" and lateral gemmation. According to Dana, the family Favositidæ was distinguished, on the one hand, from the Madreporidæ by the possession of tabulæ, and, on the other, from the Poritidæ by the fact that the tabulæ were replaced in these latter by spongy calcareous secretions, making the corallum everywhere equally finely porous.

This juxtaposition of *Alveopora* with the Favositidæ was rejected by Milne-Edwards and Haime, who expressed surprise * that the Alveopores, "which, in a manner, offer an exaggeration of the characters of *Goniopora* and of *Porites*, and in which the 'endotheca' is altogether rudimentary," are separated from these latter and placed at the head of a series containing *Favosites*, with its pronounced walls and numerous tabulæ. They accordingly placed *Alveopora* among the Poritidæ, while the Favositidæ are placed in a section, Madreporaria tabulata, of equal value with their other great sections, Madreporaria aporosa, Madreporaria perforata, Madreporaria tubulosa, and Madreporaria rugosa.

It is worth noting that Milne-Edwards and Haime, in thus separating *Alveopora* from *Favosites* on the ground of the tabulæ in the latter, overlooked the fact that Savigny figured his *Alveopora* from the Red Sea with tabulæ, as did also Dana his *A. spongiosa* from Fiji. Milne-Edwards and Haime made no mention of these tabulæ either in their generic or specific descriptions of the genus *Alveopora*.

In 1870, Saville Kent † reasserted the relationship between *Alveopora* and the Favositidæ, and proposed to establish a new transition genus, *Favositipora*, for a specimen of *Alveopora* with well-developed tabulæ which he found in the Paris Museum. In thus making the presence of tabulæ a generic distinction, Saville Kent followed Milne-Edwards and Haime in overlooking the tabulæ in *Alveopora*. Verrill, however, in 1872 pointed out the serious omission made by these authors, and rightly claimed Saville Kent's "*Favositipora*" as identical with *Alveopora*, but agreed with this author in claiming the genus *Koninckia*, M.-E. & H., from the Cretaceous, as a connecting link between the recent *Alveopora* and the Palæozoic Favositidæ. But, while

* "Monographie des Poritides," Ann. Sci. Nat. (3) xvi. 1851, p. 23.

† Ann. & Mag. Nat. Hist. vi. 1870, p. 386.

reasserting this relationship, Verrill accepted the close affinity between *Alveopora*, *Goniopora*, and *Porites*, and proposed to rearrange the Poritidæ so as to include three sub-families:—(1) Poritinæ; (2) Alveoporinæ, for *Alveopora*, *Goniopora*, *Litharæa*, and *Koninckia*; (3) Favositinæ *.

To this arrangement Nicholson † very rightly objected that the Palæozoic Favositidæ could hardly be ranked as a mere sub-class of the recent Poritidæ; he nevertheless accepted the affinity between the two families, the genus *Alveopora* being to all appearances allied to both.

Since then the Favositidæ have passed under a cloud. The disappearance of Milne-Edwards and Haime's Madreporaria tabulata involved almost all the genera which those authors placed in this section of their great coral system. Duncan ‡ dismissed them from his revision of this system with a very few words, leaving *Alveopora* among the Poritidæ. Ortmann § leaves them out of his system, and makes *Alveopora* a transition form between *Porites* and *Montipora*. Miss Ogilvie ‖ also appears to ignore the Favositidæ, but places the Alveoporinæ as a sub-family of the Madreporidæ, while the Poritidæ stand uncertainly apart from all other Madreporaria.

Lastly, while endeavouring to establish the affinities of the Palæozoic tabulate corals with the Alcyonaria, Dr. F. W. Sardeson ¶ admits that it would be difficult to show that *Favosites* and *Alveopora* are not related, but he knows of no proof that they are.

We may, then, sum up the position, which was generally adopted before the Madreporarian affinities of the Favositidæ fell into disrepute. The genus *Alveopora* is closely allied through *Goniopora* to *Porites*, while, on the other hand, its extraordinary resemblance to certain Palæozoic Favositidæ, *e. g.* *Favosites*, Lamarck, and *Aræopora*, Nich. & Eth. jun., cannot be dismissed without some recognition. In spite of the enormous interval of time, with only the indifferently described *Koninckia*, M.-E. & H., of the Cretaceous connecting them, some relationship

* Amer. Journ. Sci. 1872 (reproduced in Ann. & Mag. N. H. (4) ix. p. 355).

† 'Palæozoic Tabulate Corals,' 1879, p. 36.

‡ Journ. Linn. Soc. xviii., 1884.

§ Zool. Jahrb. (Syst.), iv., 1889.

‖ Phil. Trans. vol. 187, 1896.

¶ N. Jahrb. Min. x. (supplementary vol.), 1895–96, p. 249.

between them seems to be demanded in order to account for such a remarkable family likeness.

The problem was at this point taken up by me on commencing the fourth volume of the British Museum 'Catalogue of the Madreporaria,' which is to deal with the Poritidæ. As was to be expected, the new light which in recent years has been thrown on the morphology of the coral skeleton by the works of Bourne, Fowler, v. Heider, von Koch, and Miss Ogilvie, enables one to carry the question a step or two nearer solution than was possible to the earlier workers. Further, the unrivalled coral collection in the Natural History Museum, for my introduction to which some three to four years ago I am indebted to our President, Dr. Günther, afforded opportunities of extended observations and comparisons which are all important in the solving of questions of affinity.

The net result of my investigation has been to divorce *Alveopora* wholly from the Poritidæ, and to re-state Dana's claim to find its nearest allies in the Palæozoic Favositidæ; and the best way in which I can make my argument clear will be to describe the essential features of the genus *Alveopora*, and then to compare them, on the one hand, with those of *Favosites*, and on the other with those of the Poritidæ. I here take the opportunity of thanking my friends Prof. Jeffrey Bell and Dr. Gregory—the former, who is however in no way responsible for the opinions expressed, for much valuable assistance and advice; the latter for giving me the freest access to the valuable collections under his charge, and for the interest he showed in the whole subject I was proposing to discuss.

The Genus ALVEOPORA.

Figs. 1, 2, and 3 (Pl. 33) show three stages in the early growth of *Alveopora*. I was fortunate enough to discover them grouped together on the under surface of the type specimen of *Montipora pilosa* collected by Dr. Willey at the Loyalty Islands. They are too young to specify, but may perhaps belong to the original species of Quoy and Gaimard, *A. viridis* from New Ireland.

Fig. 1 shows an almost cylindrical epithecal cup 1 mm. across, with a few septal spines projecting from its walls rather deep down. The wall of the original polyp is thus wholly formed of epitheca.

In fig. 2 the original polyp has given rise to others. The skeletal divisions between the component polyps of the young colony are, to all appearance, wholly formed by the meeting and fusion of septal ingrowths, while their outermost walls are of epitheca. The rim of the epithecal cup is bulged and bent outwards round each polyp.

In the third stage (fig. 3) the process of adding new polyps has been continued further, the skeletal and purely septal walls between the polyps rising high up in the centre of the cup, considerably above the level of the rim of the epitheca.

In figs. 2 and 3 we get further insight into the method of the early formation of the skeleton of the bud. A low skeletal arch rises off the epitheca, between which and the epitheca is the minute fossa of the young bud, while on the outer side of the arch the septal spines of the parent project. This arch must be explained as due either to the meeting and fusion of two septal infoldings, or of two other infoldings which are not septa. This latter alternative seems to me quite unnecessary: the septal infoldings are there, and the fusion and modification of two adjoining septa to form the arch is easy to understand. We are, however, fortunately not left without some evidence of this important morphological conclusion, viz. that the dividing walls in *Alveopora* are due to the interlacing of septal spines.

1. A survey of a great number of specimens belonging to different species shows that a very intimate connection exists between the septa and the walls; if the septa are thick, the walls are thick and solid: if the septa are wiry and thin, the walls are delicate and fragile.
2. The lattice-like character of the intervening walls is common to every species, and is therefore a primitive characteristic of the genus. This is just what would arise in walls built up of septal spines fused together in one plane.
3. The septal spines in any calicle project as frequently from the transverse as from the vertical bars of the latticework, which makes it improbable that these vertical bars are septa and the transverse synapticulæ.
4. If a great number of the minute arches of young buds be examined under a pocket-lens in a well-cleaned adult stock, while it is true that their homology with septal spines is most frequently as much obscured as in figs. 2 and 3, yet

now and again a case is found which shows this homology to be the correct one.

I have somewhat elaborated this, to my mind, almost obvious conclusion, because it is essential to a right understanding of the morphology of the genus. Just as the corallum of the Madreporidæ, as I have elsewhere shown, is built up above the epitheca out of the radial structures—septa with their synapticular supports—so also is the corallum of *Alveopora* built up within the epithecal cup out of fusing septa. But there is a fundamental difference between the two: in *Alveopora* there are no continuous septal laminæ, no synapticulæ, and consequently no inner thecal wall supplementing the epitheca; hence no costæ and no cœnenchyma. These peculiarities of the genus, which separate it from all other recent Madreporaria, will be repeatedly insisted upon in the following pages, but are mentioned here in this sketch of the genus, inasmuch as v. Koch *, who was not so fortunate as I have been in having young stages to examine, thought that the skeleton of the bud was walled round by thin synapticulæ which united the septa, and that hence the budding might be called "Zwischenknospung." Whereas it seems to me that if the calicle-walls of *Alveopora* are really primarily due to the fusion in one plane of septal spines, not only is the word "theca" not applicable, but the word "synapticulæ" is equally inapplicable; and, lastly, that the budding cannot, at least very felicitously, be called "Zwischenknospung." The method of reproduction should in fact be called, in the ordinary terminology, "intracalicular gemmation," although it is increasingly clear to me that much of this terminology will require revision. For, as we shall see later on, this is in all probability in reality a case of lateral budding.

One result of this method of increase is that the original parent polyp of the colony ceases very early to be recognizable. Only in vertical sections could the identification be made, the parent being the one which runs down into the apex of the original epithecal cup.

The growth forms assumed by *Alveopora* are not numerous. If the budding takes place chiefly close to the epitheca, expanded layers are formed with a prominent epithecal rim. If the budding takes place chiefly in the centre of the young colony, the stock forms nodules or thick columns which may branch. In

* Gegenbaur's Festschrift, ii., 1896; see also Morph. Jahrb. xxiv., 1896.

these cases the epitheca changes its function; it ceases to be mural and becomes pellicular, covering over the basal calicles as they progressively die. It is worth noting that this pronounced epithecal pellicle can at any time resume its original functions, bending outwards and forming part of the walls of new buds.

In the formation of these colonies it must be noted that the skeletal walls of the calicles not in contact with the mural (as opposed to pellicular) epitheca are, as above maintained, purely of septal origin, while those round the periphery have part of their walls formed by the epitheca.

As the colony grows in height, the living polyps rise in the calicle-tubes, and their free bases often secrete "tabulæ." The rising may be practically simultaneous over the whole colony, in which case a tabulate plate will run more or less continuously through the whole colony (see Savigny's figure of *A. dædalea* and Dana's of his *A. spongiosa*).

Favosites.

Nearly all the characters above described for *Alveopora* apply equally well to the Palæozoic genus *Favosites*. Very young colonies have been described and figured by Hall (*cf.* Indiana Geol. & Nat. Hist., 11th Report, 1881, p. 229, pls. 1 & 3), by Milne-Edwards and Haime (British Fossil Corals, p. 185, pl. 60), and by Nicholson (Palæozoic Tabulate Corals, 1879, pl. i. fig. 3), although none are quite so young as the oldest here figured (Pl. 33. fig. 3). From these we see the same prominent epithecal cup and the same early obscuration of the parent polyp. Indeed, all the general characters of the colonies, young and old, appear to be the same—the polygonal calicles, their thin walls, the mural pores, and the spiny septa. Lastly, the method of budding appears also to have been the same, as v. Koch, who has published sections of the two for comparison, admits *. Before, however, this last point can be established, it is necessary to discuss the character of the walls between the polyps of a *Favosites* colony.

From all the ordinary descriptions of *Favosites* we gather that each calicle has its own distinct wall, but that these walls are intimately fused together by the crowding of the calicles, which is so close that they press one another into polygonal prisms.

* Compare 'Palæontographica,' xxix. p. 329 (1883), with Morph. Jahrb. xxiv. 1896, p. 167.

Now I admit that there is more to be said for this view than I was at first inclined to allow. But the usual argument employed in its favour is not conclusive. We are referred to the black median line which runs through the walls when studied in thin sections under the microscope. It is not necessary to discuss the many different views which have been held in the past as to the real nature of this black line. I need only refer readers, on this point, to the recent work of Miss Ogilvie (*l. c. antea*), where the history of the subject is reviewed and the matter is fully and, from the existing standpoint, adequately discussed. The black line simply means that this apparently double wall was secreted by a continuous fold of tissue. Similar black lines are invariably found down the middle of septa secreted by ectodermal folds; hence we should expect them to appear in the walls of calicles which are built up of septa, as explained for *Alveopora*.

Figs. 4 and 5 are drawn by Mr. Percy Highley from sections of the Palæozoic *Favosites gothlandica* and of a recent *Alveopora*. We find the same black line running down the middle of the skeletal framework in both cases. That in the fossil is slightly more pronounced than that in the recent coral, but there is no reason whatever to believe that they were dissimilar in origin. Besides, I have seen it stated somewhere, I think by Miss Ogilvie, that the black streak is usually much more pronounced in Palæozoic than in recent corals.

We are then, I think, fully justified in claiming that in *Favosites* the perforated calicular walls may have arisen, as in *Alveopora*, from the meeting and fusion of the septa, and are not the outer walls of separate and distinct polyps. This claim seems to me to find further support when the common epithecal cup, which is known to have contained the young colonies of *Favosites*, is taken into consideration. Within such a cup, the fission or gemmation of the polyps for the formation of such a compact stock as that of *Favosites* could, it would seem, hardly proceed in any other way than that which we have described for *Alveopora*. Further, a study of the section of *Favosites* (fig. 4) shows this same black line not contained only in the walls but running up the septal spines *, as we should expect it to do on the assumption that the walls are septal structures, while it is hardly consistent with the usual explanation that the black line repre-

* *Cf.* also v. Koch's section of *Alveopora*, in which the same is shown.

sents the line of fusion of two outer walls *. In the same figure it will be noticed that at each point where the walls meet there is a star. These stars appear to be of the same nature as the black lines; but as it is just possible that they may be secondary results of fossilization and cracking, I would not lay too much stress on them. If, however, they are what they appear to be, they afford additional evidence as to the nature of the black line, viz. that it was secreted under a rising ectodermal fold; its starring at the angles may be intelligible from this point of view, but is certainly unintelligible at the meeting-point of three outer walls.

We have thus, it seems to me, enough evidence to show that there is apparently no fundamental morphological difference between the recent *Alveopora* and the Palæozoic *Favosites*. Both start in an epithecal cup, new calicles are marked off from the parent calicle in the same way *, *i. e.* primitively by septal spines, which in fusing secondarily become lamellate walls, and this process goes on until a colony is produced all within the same epitheca. All the calicles produced in the central regions have their walls purely septal, while those close against the epitheca have their walls partly formed by it. As in *Alveopora*, again, each new calicle is apparently marked off from one of the angles of its parent. And, lastly, the skeleton of *Alveopora* in its earliest stage has every claim to represent a very primitive form of the Madreporarian skeleton (see below).

So far, then, we see no valid reason why the modern *Alveopora* should not be classed with *Favosites* as one of the Favositidæ, as proposed by Dana. But how far the genera usually placed in this family † are related to one another can only be decided by careful study of each separately from the new point of view. I would now merely confine myself to calling attention to the Devonian genus *Aræopora* of Nicholson and Etheridge jun. as showing very striking resemblance to the modern *Alveopora*.

The chief difficulties in the way of this association appear to lie in the facts (1) that, with the exception of the little-known genus *Koninckia*, M.-E. & H., from the Cretaceous, no connecting links have been found or suggested to tide over the enormous interval of time which has elapsed since *Favosites* flourished; (2) that it does appear possible * to explain the

* But see Postscript, *infrà*, p. 515.

† *Cf.* the list given by Nicholson in his Pal. Tabulate Corals, pp. 35-36.

formation of the walls of *Favosites* somewhat differently from those of *Alveopora*. With regard to the former of these, I do not think this difficulty can override the morphological evidence, first, that *Alveopora* in its earliest known developmental stage is very primitive, and hence would naturally have its nearest allies in Palæozoic times; and second, that no essential structural difference can be proved to exist between it and the Palæozoic *Favosites*. The choice, it seems to me, lies between direct genetic relationship and redevelopment of an archaic type.

With regard to the second point, it in no way affects the main conclusion that *Alveopora* finds its nearest allies among the Palæozoic Favositidæ. The working out of this point would mean the settling of the exact affinity between *Alveopora* and the genus *Favosites*. My investigations on this difficult point are very incomplete; see, however, the Postscript to this paper.

On the supposed Relationship of Alveopora *with the* Poritidæ.

This relationship, as we have seen, has been very generally assumed. Milne-Edwards and Haime declared that *Alveopora* was in a manner but an exaggeration of *Goniopora*. The advance which has been made in our knowledge of the coral skeleton leads me to believe that this view is wholly untenable—*Alveopora* and the Poritidæ standing at opposite extremes of the coral system. I can best explain by a series of diagrams the conclusions at which I have arrived after four years of close study of hundreds of different coralla with the express object of unravelling the lines of development along which the different genera have travelled.

1. (Fig. 6.) The primitive skeleton of the coral polyp was an epithecal cup. The evidence for this I would find in its apparently universal appearance in the earliest stages of development, and always with a uniformity of shape, texture, and function, in striking contrast to the marvellous variety of skeletal superstructures which have been secondarily built upon it. In some Palæozoic corals it appears to form the greater part of the skeleton and was, as a rule, a prominent structure. The very slight systematic importance which has been hitherto attached to it is due to the fact that in recent corals it is to a great extent vestigial, the vestiges being difficult to explain; and, further, it only appears in its original capacity as a recognizably mural structure in the very earliest stages of colony formation, very

few of which early stages have been described. Further, the argument may be advanced that the skeleton formed by the secretions of the smooth outer skin of the original coral polyp preceded the complicated internal skeletons, which may be regarded as having been due to local irregularities in the amount of the secretion pushing in the skin into complicated folds, which folds continued to secrete skeletal matter. Further, it seems to me, that the conclusions arrived at by v. Koch and summed up in his recent paper in Gegenbaur's 'Festschrift,' vol. ii., are essentially in accord. It may, perhaps, be of use topographically to distinguish between basal plate and epitheca; but we owe so much to v. Koch in unifying our conceptions of the morphology of the Madreporarian skeleton that it seems quite in a line with his own teaching to speak of foot-plate and epitheca as forming together a primitive epitheeal cup. I would even go further in the same direction and claim, as above suggested, not only that an epitheeal cup was the primitive coral-wall, but that the whole of the septal skeleton built upon it was due to infoldings of the same secreting surface. From this point of view, the whole of the internal septal skeleton may be regarded as an infolding of the epitheca, the median black line showing where the skeletal surfaces are apposed. In this way I think the skeleton of *Flabellum*, as revealed in sections *, receives its simplest interpretation. I am therefore quite in accord with v. Koch in regarding the external wall of *Flabellum* as a secondarily thickened epitheca. I may add that this secondary thickening of the epitheca is quite a common feature in the genus *Montipora*.

The skeleton of the parent polyp of an Alveoporan colony is in the stage illustrated by the diagram (fig. 6), in which the primitive deep epitheeal cup has become provided with septal spines, which were not primitive.

II. (Figs. 7, 8, 9.) The septa, which early became laminate, owing perhaps to an ever increasing deposition of skeletal matter between the mesenterics, formed in time a ring of tall, radially arranged plates, which rose high above the rim of the epitheeal cup; this latter, in many cases, widening out considerably as a saucer-shaped basal plate. This ring of radial exsert laminæ

* *Cf.* the figures given by Dr. Fowler and Mr. Bourne in their articles in the Q. J. M. S. xxviii. 1888, and by v. Koch in Gegenbaur's 'Festschrift,' vol. ii. Ortmann's figure, which differs from these, will be discussed further on.

obtained mutual support in two ways:—(*a*) As the septa grew in height, the polyp continually withdrew from its original epitheeal deposit and secreted series of dissepiments; these are a marked feature in many Palæozoic corals, and still, as I believe, form the true thecal wall in many Astræids, as shown in fig. 10. (*b*) The septa thickened at one or more points, the thickened parts met across the intervening spaces and fused, displacing, in so doing, the soft parts at the spots affected; this process is only a further complication of the original infolding of the ectoderm for the formation of septa.

Having thus far digressed with a view to explaining my morphological standpoint, the details of which will be dealt with more fully presently, we return to the question as to the generally accepted affinity between *Alveopora* and *Goniopora*.

The skeleton of the parent polyp of *Alveopora* stands, as we have seen, at the lowest level shown in our diagrams, while *Porites* stands at the opposite extreme. The deep conical cup of *Alveopora*, with its trabecular septa running horizontally inwards, is represented in *Porites* by a flat saucer-shaped epitheca with the trabecular septa pointing upwards and united both radially and concentrically with one another. In this way *Porites* may have been deduced from a stage like that of fig. 6. But whereas in *Alveopora* the later internal septate skeleton is purely septate, in *Porites* the subsequent growth is septate and thecate. The septa in *Porites*, though not laminate, consist of radial series of vertical trabeculæ joined together in such a way that each series may perhaps be regarded as a highly perforate lamellate septum. Further, these trabeculæ are united by synapticulæ, that is, by bars running concentrically round the calicle, so that the whole skeleton is a kind of lattice-work made up of vertical and horizontal bars. The highest part of the septa comes, as in most other thecate corals, at some distance from the outer ends of the septa: we have thus trabecular costæ and also an "edge zone" from which the polyps bud, the skeleton of each bud being formed upon the costal portion of its parent skeleton and thus what is called extra-calicular. *Goniopora* appears to differ from *Porites*, not only in the size of the calicles, but in the fact that the highest points of the septa run up so as to form a tall thin ring of perforated tissue round each fossa, whereas there is no such sudden rise of one or more trabeculæ of each septum in *Porites*. There are other

differences which need not now concern us, and I propose to deal with these fully in the 4th vol. of the Museum Catalogue on which I am now engaged.

The Poritidæ thus appear to me to establish their claim to stand at the extreme end of the septate thecate series, as perforate corals *par excellence*. Their nearest rivals are the Madreporidæ, in which the laminate septa with their synapticular junctions not infrequently dissolve down into a reticulum; this reaches an extreme in the genus *Montipora*. The fundamental distinction between the Madreporidæ and the Poritidæ appears to lie solely in the fact that in the former the septa are typically laminate however much the lamination may have been secondarily obscured, while in *Porites* the septa are typically series of trabeculæ.

The problem as to the relationship between these two great recent families has still to be worked out. It may be stated briefly as follows:—Are the trabecular septa secondary modifications of the laminate or *vice versâ*? or, again, are they two independent developments (that is, infoldings) of the primitive epithecate skeleton, in both cases leading to the flattening out of the primitive cup as here suggested (*cf.* figs. 6–9)? The answers to these questions will most likely come from palæontology. I note that Miss Ogilvie is inclined to class the Poritidæ separately; and it cannot be denied that the series of comparatively speaking low trabeculæ which form the septa suggest the persistence of a primitive character. I do not see that we have enough evidence at present to enable us to come to any definite conclusion.

Further Notes on the Phylogenetic Development of the Madreporarian Skeleton.

Thecal formations.—We have noted (figs. 9 & 10) two ways in which *internal* skeletal walls have been built up, replacing the original external epithecal cup. These internal walls have been called thecæ, although I am convinced that they have had very different origins, and it will in the future become necessary to distinguish these differences in any natural classification of the Madreporaria.

The dissepimental theca (fig. 10), which I should like to suggest might afford the diagnostic character of the Astræidæ, is a very different thing from the synapticular theca (fig. 9), using the word synapticula for any fusion across the interseptal space due to local

thickenings of the septa themselves. My attention was first called to these dissepimental thecæ by studying the growing edge of an Astræid colony (not yet classified). The thick round-topped theca was rising between the young septa, and was so obviously dissepimental that when I applied a pin it punctured like thin paper. On looking over other Astræids I found the same dissepiments, in all stages of obscuration however: fusions of the septa *inter se* had taken place, but closer examination showed that in many cases, even when the synapticular theca was developed, from the uppermost wall of the theca dissepimental floors sloped away both inwards and outwards; in some cases again only the external, in others only the internal dissepiments were now recognizable. It has of course long been known that the rich development of dissepiments was a characteristic of the Astræids, and Martin Duncan* even claimed that the "true theca" of *Cœloria* and of *Leptoria* had been "replaced" by epithecal nodules. Further, this very rich formation of dissepiments mounting to the level of, if not actually forming, the theca doubtless suggested to Milne-Edwards and Haime their great section *Madreporaria aporosa*, for thecæ so formed, or at least covered, would necessarily be imperforate.

I must here, however, perforce content myself with merely throwing out this suggestion. Its elaboration will require an extended study and sorting out of the different genera now commonly classed together as Astræidæ. For in addition to the dissepimental theca, there appears to be another common among "Astræidæ," the origin of which will be discussed later on.

So much has been written about the synapticular theca—the "pseudotheca" of von Heider—that I need say little about it. It can hardly be looked upon as a structure *sui generis*, being essentially septal in origin, and only a further complication of the original ectodermal infolding, and developed apparently for the mutual support of the tall septal plates (*cf.* figs. 8 & 9). The synapticular theca would obviously be much stronger than the dissepimental, and more readily obtained by the multiplication of the septa.

Before dismissing this subject of thecal formation it is well to ask whether there may not be another, namely, a true circular fold of the basal ectoderm of equal value with the septa as a direct infolding of the external body covering, and interrupted by the

* Journ. Linn. Soc., Zool. xvii.

septa but uniting them *inter se*. This would be the theca proper, the 'eutheca' of v. Heider and Ortmann. I cannot decide this point for want of direct evidence—the sections of *Galaxeá*, *Lophohelia*, and *Turbinolia* seem to require it. But there is a possible explanation of at least the two latter of these without imagining a distinct circular thecal fold. It is as follows:—The soft polyp growing faster than its rigid epithecal cup, tends to overflow it. I believe this to have been a very common occurrence in the earlier coral ages, and it still occurs, as will be presently shown. In the meantime, let us suppose that in *Turbinolia* and *Lophohelia* the Randplatte is no true Randplatte—that is, a portion of the cœlenteron passively cut off by the upgrowth of a theca, but that it is merely a lap of the soft parts bulging down over the rim of the cup, above which rim the septa projected. This would give us all the appearances shown in Fowler's sections of *Lophohelia* *, Bourne's of *Euphyllia* †, and Miss Ogilvie's of *Turbinolia* ‡. The "theca" would in this case be really the rim of the primitive epithecal cup slightly folded over; and from it septa could be infolded (see Fowler's fig. 5). As some confirmation of this I would call attention to the fact that Ortmann's figure of *Flabellum* § shows a circumferential dark line, whereas no other recorded figure shows anything of the kind. I venture to suggest that in Ortmann's specimen the soft parts bulged somewhat over the lip of the epithecal cup, and that this caused a slightly folded rim.

With regard to the section of *Galaxea*, I do not see why the same explanation should not apply, only, in this case, the lap of the more rapidly growing soft parts has reached an extreme, and bagging down has united with those of adjacent polyps to secrete the "cœnenchyma" which characterizes the genus. I should not, then, be inclined to call these circular folds of epitheca "thecæ," for fear of confusing them morphologically with the synapticular and dissepimental thecæ, but by some term implying that they are only the rims of the primitive epithecal cups folded back close against their sides. Again, as already stated, I should distinguish between this overflowing Randplatte and that due to the upgrowth of a theca from the floor of the cup.

With regard to the fate of the primitive epithecal cup shown

* Quart. Journ. Micr. Sci. xxviii., 1888. † *Ibid.*

‡ Phil. Trans. 1896, p. 248, fig. 73.

§ Zool. Jahrb. iv. (Syst.) 1889, pl. xviii. fig. 9.

in the diagram, we note that wherever a true theca is formed, the epitheca tends to be pushed more and more into the background, so as to become quite vestigial, and that this is the case in the great bulk of the recent Madreporaria. It is further to be noted that the possibilities of colony-formation are enormously increased in the more purely septate skeletons than they ever could have been in the primitive epithecate stage. The height and development, number and character of the septa, the position and character of the uniting tissue to which, when not dissepimental, I give the general term "synapticular," which gives rise to the theca, may vary considerably; and every slight difference is then magnified by its indefinite multiplication in colony-formation. Further, it is fairly obvious that the forms with synapticular thecæ would show a far richer development than would those with the less plastic dissepimental thecæ.

Budding.—The remark made at the beginning of this paper that certainly some forms of "intracalicular" gemmation may be true cases of lateral gemmation is made clear by the diagrams. If a lateral bud arises (as in fig. 6) above the epithecal rim which bends out beneath it, the dividing wall between parent and bud is naturally supplied by the septal spines. We have every right to assume that this is what actually takes place in *Alveopora*: certainly the rim of the epitheca can be seen to bend out, and on the other hand we know from published figures that the polyps rise high above their skeletons. In those cases in which the epitheca in further growth encases the parent and the bud separately, we have colony-formation of purely epithecate skeletons. A very primitive colony-formation of this character has been minutely and instructively described by Beecher *.

Passing, then, from the budding of an epithecate coral which may produce either an epithecate colony, as in the example cited, or a colony in which the epitheca of the parent polyp becomes a common epitheca to the whole colony, the skeletons of individuals being septate but not thecate—e. g. *Alveopora*, and apparently *Favosites*,—we come to the budding of polyps with purely septate skeletons. We note from the diagrams that the budding remains the same, viz. lateral gemmation; but the form of the skeleton has changed, the rising up of the septa, with their synapticulæ for mutual support, gives a new groundwork on

* Trans. Conn. Acad. vol. viii. p. 207, 1891, pls. ix.–xiii. See also Postscript, *infrà*, p. 515.

which the bud can start its own skeleton. In describing the plan of this purely septate skeleton a number of fresh terms have to be used. For instance, the edges of the septa outside the thecal wall are called "costæ," the word *septa* being confined to the inner portions of these structures. The soft parts which surround the costal skeleton, *i. e.* the sides of the body, are now called the "edge-zone" or "Randplatte" of v. Heider. These terms are doubtless of some use, but it seems to me that their significance is more topographical than morphological. With regard to the budding, we find that the same lateral gemmation which gave rise to what was called intracalicular gemmation, when taken only in reference to the epithecate skeleton, may become what is called extra-calicular in the thecate corals. I do not, however, propose any changes in terminology, the exigencies of description must settle such matters, and, with clear conceptions as to the true morphological bearings of the subject discussed, we can safely leave the cloud of words to be sifted out by time. One rule seems to me very necessary in all future discussions on budding, the terms should be used uniformly with regard either to the polyp or to the skeleton. At present, when the skeletons form the mass of the material to hand, it is better to use terms relating solely to them.

The Randplatte.—As above stated, the rise from a basal epitheca of a septate skeleton within the polyp, naturally divides up the space within the polyp into a central fossa inside the new skeletal rampart and a peripheral region outside this rampart. The region outside this internal skeletal rampart is what is commonly called the edge-zone or Randplatte. This view is entirely in accord with v. Koch's contention* that the Randplatte has no important morphological significance, inasmuch as it comes quite passively into existence owing to the complication of the internal skeletal infoldings. The term, however, may be of use topographically. I should be inclined to suggest that it might with advantage be confined entirely to the lap which overflows the epithecal cup above described.

The Epitheca.—The connected account here given of the various parts of the coral skeleton, viz. that the most complicated internal skeleton bears the same relation to the primitive external epitheca as do the complicated internal chitinous skeletons of certain Arthropods (*e. g.* the apodematous system of the Lobster, the

* Morph. Jahrb. xiv. 1888; footnote on p. 342.

endosternite of the Spider) to their external chitinous cuticles, brings, I think, some order into a subject in which at present no small confusion prevails. How great is that confusion may be gathered from the recent work by Prof. Lacaze-Duthiers on *Balanophyllia* *, wherever the existence or non-existence of an epitheca comes into question.

One cause of the confusion arises from the fact that too much importance has been laid upon the observations which seem to show that in the development of a few corals the first skeletal elements which appear belong to the radial septa. I cannot see that any serious importance whatever attaches to this interesting observation. Given the fundamental connection between the external layer and the internal infoldings of that layer, we have absolutely no warrant to claim that the part which appears first in ontogeny must necessarily have appeared first in phylogeny. Any part of the external secretion may be secondarily suppressed, and no part would be so likely to disappear as the basal portion in immediate contact with the substratum as soon as the septal infoldings of that very region had reached any great degree of development. Indeed, I do not see why we should not get variation in the deposition of the secretion dependent perhaps upon fine differences in the character of the substratum, or perhaps upon differences of local habit. This might perhaps be the explanation of the apparent conflict between the observations of Lacaze-Duthiers and v. Koch as to whether the septa or the basal disc begin to appear first.

Given, however, a suppression of the basal disc, we should get the appearance which led Bourne † to affirm that the epitheca is secreted by the lower edge of the Randplatte, and appears as this latter follows the upward growth of the coral. Reference to the diagram fig. 8 will show how this appearance may be explained differently. The epitheca may quite as easily be regarded as an integral part of the whole skeleton, even though its basal parts are secondarily suppressed, so that it *appears* to be nothing but a ring of skeletal matter just below the Randplatte. There is, therefore, no fundamental disagreement between Bourne's observation and my claim that the epitheca is the primitive cup of the parent polyp. In the meantime the inability to reconcile these two observations is the

* Arch. Zool. Exp. 3e sér., v., 1897.

† Quart. Journ. Micr. Sci. xxviii., 1888.

real cause of the difficulties experienced by Prof. Lacaze-Duthiers (*l. c.*) whenever the epitheca comes into the discussion.

On the other hand, in his account of the development of his specimens of *Balanophyllia* and of *Leptopsammia*, Prof. Lacaze-Duthiers records not only what he had already recorded of his specimens of *Astroides*, that the first calcareous secretions belong topographically to the septa, but that an epithecal wall soon appears round the young polyp. He then noted that the septal skeleton overran this (1st) wall, which tended to limit the size of the base too much, and that then another epithecal wall (2nd wall) appears, which may be again overrun, when a third appears round the base, which has been in this way greatly expanded. This observation seems to me of considerable importance, and I am fortunately in a position to confirm it.

An examination of almost any group of young single corals developing on the corroded parts of other specimens will show the periodical overflowing of the epithecal cups as the individuals outgrow them. Figure 11 shows one such, overflowing excentrically. The first wall has been obscured by the columella. One quite overrun wall is, however, distinct, and the last formed is being overrun. Cases in which the successive walls are quite concentric have also been noted, and are probably the normal method of expanding the base of attachment. The need for widening the base of the primitive epithecal cup, which must otherwise continue to expand, cone-like, as the polyp grows, fully explains this remarkable process. In some cases it is probable that the overflow was strictly limited and local, and was then re-covered over by epitheca, in which case the conical cup would be propped up by rootlets, as in *Rhizotrochus*. I would further venture to make the suggestion that if the primitive conical coral skeleton frequently adopted this overflowing method of widening its base, the overflowing being on one side only, the radial arrangement of the septa would be interfered with, as we see to be the case in fig. 11. Persistence of the bilateral symmetry thus acquired could, I think, be made to explain some of the more anomalous arrangements of the septa among Palæozoic corals (e. g. *Streptelasma*).

SUMMARY.

Alveopora agrees in all essentials of skeletal structure with *Favosites*, and there is no other reason to doubt their genetic relationship than that which arises from the interval of time with only the little-known Cretaceous genus *Koninckia* to connect them.

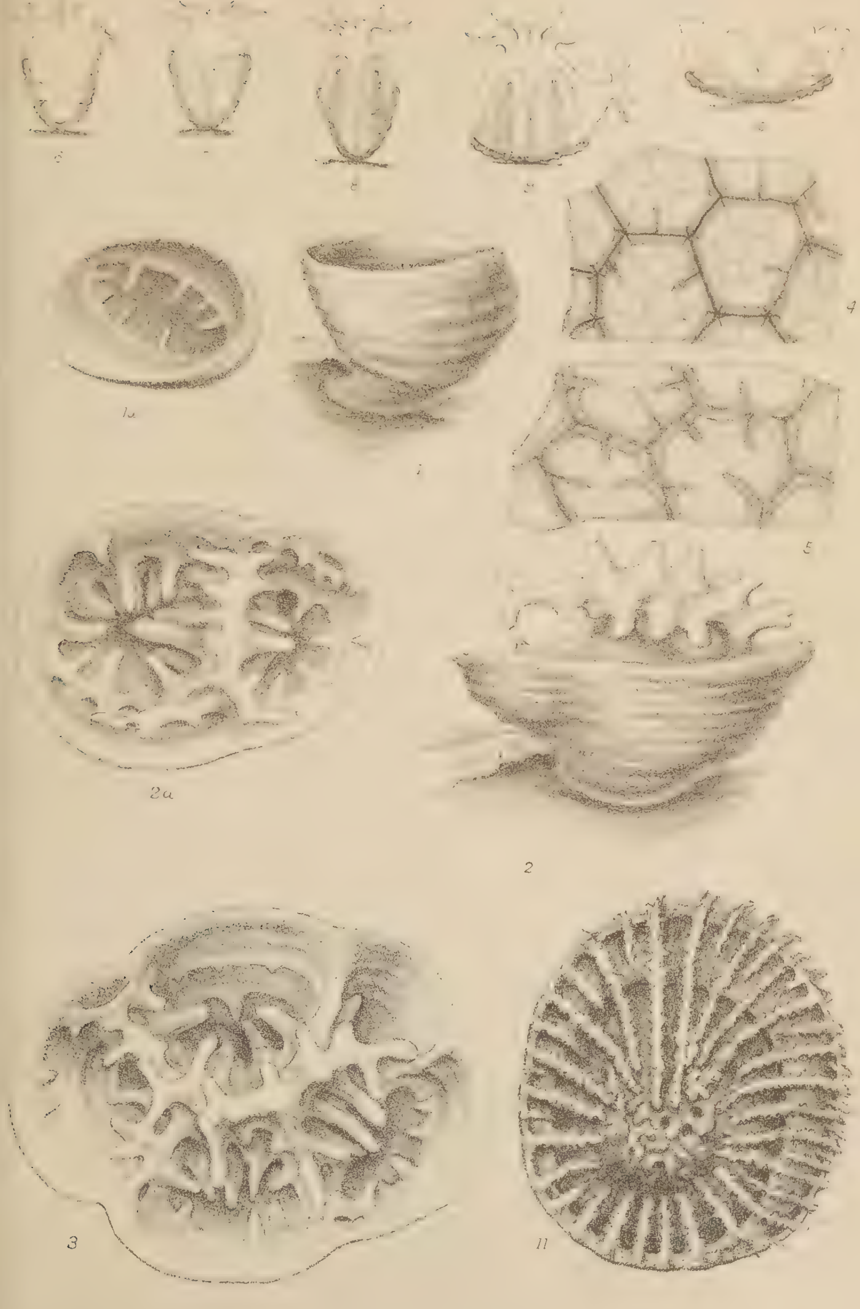
A comparative study of Madreporarian skeletons leads to the conclusion that the skeleton of *Alveopora* is at a very low level of development, and on that account alone might be regarded as the survival of a Palæozoic type.

In this respect *Alveopora* stands far away from the *Poritidæ*, with which it is usually classed, this latter standing almost at the opposite extreme of high specialization.

The Madreporarian skeleton may be described as the rigid secretion of the basal portion of the columniform body of a polyp into which the flexible upper portion may be invaginated. In its earliest development a simple cup, it has become complicated in various ways: primarily, by the development of radial infoldings of the stiff external wall, comparable with the infoldings of the chitinous cuticle of Arthropods; secondarily, (1) by further complications of these infoldings so as to form an intricate "internal" skeleton, which may render the primitive external cup unnecessary, and hence lead to its becoming vestigial; (2) by a process of repeated sheddings of the external hard secretions, and the formation of new ones across and among the existing "internal" skeletal structures (dissepiments and tabulæ).

The growing soft parts may overflow this primitive rigid cup. The bagging thus occasioned may reach the substratum and widen the base of attachment, or may merely hang down, secreting in so doing a folded rim to the cup ('eutheca' of v. Heider). This bagging is quite distinct from the peripheral region of the body which surrounds the "internal" skeleton above mentioned, and the word Randplatte cannot be applied to both. It would be better to apply it to the bagging process, which has some distinct morphological importance, whereas the alternative has only topographical utility.

I am disposed to believe that many "Astræidæ" will be found to have epithecate walls, owing to colony formation starting from this bagging of the soft parts over the primitive cup. All such, if this is correct, will have to be separated widely from those forms in which the theca is dissepimental in origin.



Highley del & lith.   Hanhart imp.

ALVEOPORA & THE MADREPORARIAN SKELETON.

I am aware that in the foregoing notes I have ventured over and over again into very debatable ground, and have touched upon many subjects which I had no intention of elaborating on the present occasion. I do not, indeed, pretend to be competent to do this. My object in thus briefly and perhaps somewhat prematurely stating these conclusions as to the fundamentals of the morphology of the coral skeleton are two,—first to make clear why I consider *Alveopora* far removed from *Porites* and *Goniopora*, and allied rather to the Palæozoic *Favosites*; and, secondly, because I think it due both to myself and to my fellow-workers in Coral morphology to state the standpoint at which I have arrived. Having before me the colossal task of redescribing and rearranging the Madreporaria, my object in so doing is to obtain, by inviting criticism, a truer conception of the evolutionary processes to which the different families owe their origin.

A detailed comparison of the phylogenetic development of the Madreporarian skeleton here set out with the schemes of Ortmann*, v. Koch†, and Miss Ogilvie‡ would involve a long and largely profitless discussion. Even when I most differ from them, I sincerely acknowledge the help I have received from them.

Postscript.—Coralla built up solely of epithecal cups seem to have been formed in other ways than that described by Beecher (*l. c. antea*). "*Beaumontia*" [*cf.* Reuss, Novara Exp. (Geol.) ii. Taf. iii. fig. 9] appears to have been such a colony, and can, I think, best be explained as built up by the overflowing method above described. This would give the thin double wall found here and in *Favosites*. But we still have the mural pores and the horizontal spiny septa uniting *Favosites* with *Alveopora*.

EXPLANATION OF PLATE 33.

Fig. 1–1 *a*. View from the side and from above of the skeleton of the youngest or parent polyp-stage of the genus *Alveopora*. The cup has been bent round towards the light. A few septal spines are seen far down the cup. Magnified about 15 diameters.

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* Zeits. wiss. Zool. 1890, p. 278.

† Gegenbaur's Festschrift, p. 272.

‡ Phil. Trans. vol. 187 1896, p. 316.

Fig. 2–2 *a*. Views from the side and from above of a later stage in which the colony consists of three or four polyps contained within the same epitheca.

3. View from above of a still later stage.

4. Transverse section of a specimen of the Palæozoic *Favosites gothlandi a*, showing the black median line in the walls, which can here and there be seen to run into the septal spines and at the angles to form stars.

5. Transverse section of a recent *Alveopora*, showing the same black line in the walls and running into the septal spines.

6. Diagram of an early evolutionary stage in the Madreporarian skeleton (*cf.* figs. 1–1 *a*), an epithecal cup with septal spines; the bud appears over the rim of the epitheca. The thickness of the epitheca in this and the following diagrams is purposely exaggerated.

7. The septa are laminate.

8–9. The laminate septa have risen above the rim of the epithecal cup and have fused by means of local thickenings (shaded areas). The epitheca becomes vestigial, the new internal wall formed by the fused local thickenings of the septa, called the theca, divides the primitive septa into septa and costæ. The portion of the body of the polyp which covers the costæ is called the "edge-zone" or "Randplatte," and the buds develop from it.

10. Diagram of the parent polyp of an Astræid colony (as here limited); the new internal wall or theca, which supports the septa, is here formed of dissepiments.

11. Sketch (× 7) of the skeleton of a polyp showing overflowing of the epithecal wall by the septal portion of the skeleton (*cf.* text, p. 513).

On the Histology of the Salivary, Buccal, and Harderian Glands of the *Colubridæ*, with Notes on their Tooth-succession and the Relationships of the Poison-duct. By G. S. West, A.R.C.S.Lond., Scholar of St. John's Coll. Cambridge.*

[Read 17th February, 1898.]

(Plates 34 & 35.)

During the continuation in Cambridge of my work upon the poison-apparatus of Snakes, commenced at the Royal College of Science, London, upon which the Linnean Society have already down me the honour of publishing a paper (Journ. Linn. Soc., Zool. vol. xxv. p. 419), several matters have arisen which require further consideration, more particularly as concerning the histological structure of the glands of the head, the nature of their secretion, and the succession of the poison-teeth. In the study of the more minute structure of the glands, one of the greatest difficulties met with was to procure specimens of poisonous snakes sufficiently well preserved for such histological purposes, and for this reason but few of the specimens examined have been of real use in the preparation of this paper.

The Glands.

The Unicellular Glands.—The mucous membrane of the mouth of snakes is thrown into a series of *longitudinal folds*, variable in number and character, but usually conspicuously present on each side of the pterygoids, maxillæ, and mandibles. This folding increases the area of the buccal epithelium, and as the latter is of a secretory nature †, it must be regarded as an arrangement accessory to deglutition. The epithelium for the most part consists of unicellular mucus-secreting glands. In some snakes (e. g. *Dryophis mycterizans*) these secretory cells are more or less ovate goblet-cells; in others (e. g. *Bungarus ceylonensis*) they are columnar cells with somewhat acutely rounded bases, and all possess a striated free border of considerable thickness (about 6 μ). In many of the specimens which had not been well preserved this border was dissociated into a large number of vertically arranged rods, readily differentiated

* Communicated by Prof. G. B. Howes, F.R.S., Sec. Linn. Soc.

† G. S. West, "On the Buccal Glands and Teeth of certain Poisonous Snakes," P. Z. S. 1895, p. 814 (footnote).

by those reagents which were utilized for staining the rest of the cell. The nucleus is an oval, coarsely granulated body, generally embedded in a cup-shaped layer of protoplasm lining the basal portion of the cell. With regard to the staining, very good results were obtained with Safranin and Orange, and Eosin and Dahlia. Another noticeable feature is that in surface view the epithelial cells appear rounded (Pl. **34**. fig. 3)*, and not polygonal as in the case of ordinary columnar epithelium. Many of the secretory cells retain their nucleus (figs. 1 & 2, *ep.gl.*), and it would appear that whereas these are enabled to again perform their function, an entire cessation of functional activity has taken place in others in which the nucleus had become dislodged (figs. 1 & 2, *ep.'gl.'*). The latter effete cells are replaced from below by certain *proliferating cells* set apart for the purpose (fig. 2, *p.c.*) †.

In the Hydrophiinæ, or Marine Snakes, the lining epithelium of the mouth is not so markedly secretory, the gland-cells being narrower columnar cells confined to a few shallow folds of the mucous membrane.

Towards the sides of the mouth a conspicuous change takes place, the secretory cells become much fewer, shorter, and broader, and the interstitial cells increase proportionately in number and in length (fig. 4); also a more or less definite cuticle appears to be formed over the free borders of the cells, and the secretory cells disappear, being ultimately replaced by rounded-polygonal cells with large granular nuclei.

The Labial Glands.—The disposition and composite nature of these glands, which are solely mucus-secreting, I have described elsewhere, but I now wish to consider certain points in greater detail. They are developed to the greatest extent in the Aglyphous Colubridæ, and to a larger degree in the Opisthoglyphous than in the Proteroglyphous forms; in the latter there is a marked aggregation of the glandular tissue at the anterior extremity of the upper jaw, more especially noticeable in the Hydrophiinæ. In some Opisthoglyphous forms ‡ the superior

* Polygonal contours could not be detected when specially sought for.

† *Cfr.* remarks on the fat-cells of the hepato-pancreas of the Crayfish by J. Frenzel, "Die Mitteldarmdrüse des Flusskrebses und die amitotische Zelltheilung," Archiv f. mikr. Anat. 1893, Bd. xli.

‡ *Erythrolamprus Æsculapii*; *cfr.* G. S. West, "On two little-known Opisthoglyphous Snakes," Journ. Linn. Soc., Zool. vol. xxv. p. 420 (1896).

labial gland consists of two isolated portions; and in all the Colubridæ the lining epithelium of the ducts, even to within a very short distance of their orifices, consists of secretory cells similar to those of the alveoli. The latter are large and somewhat irregular, and the lumen varies in size considerably in the different groups of snakes. In the Proteroglyphous Colubridæ the lumen is large and the epithelium is but one layer of cells thick. In the Aglyphous and Opisthoglyphous forms, however, the epithelium consists of several layers of cells and the lumen of the gland is correspondingly smaller. A drawing is given in fig. 9 (Pl. 35) of the resting state of the gland in a species of *Heterodon*, and in it the small size of the lumen as compared with the size of the alveolus is most clearly seen. A few alveoli from the superior labial gland of an Opisthoglyphous snake, *Dipsas ceylonensis*, killed during active secretion, are represented in fig. 10. A consideration of these two figures affords distinct evidence that the mucus-secreting cells are for the most part disorganized and discharged during secretion; this could only be inferred from fig. 9, as those cells not adjacent to the lumen of the alveoli would be unable to discharge their secretory product without the disorganization of those that intervene, but in fig. 10 this disintegration of the mucus-secreting cells is clearly shown. The preparations leave no doubt in my mind that these cells are replaced by others which arise by proliferation of certain subepithelioid cells (*p.c.* fig. 10) located towards the exterior of the alveoli and more or less flattened against the basement-membrane—cells which are evidently the homologues of those known to the human anatomist as the 'marginal cells,' constituting the *crescents of Gianuzzi* or the *demilunes of Heidenhain* *.

It has been stated by certain physiologists that broken-down mucus-secreting cells rarely, if ever, occur, and that a supposition that any considerable breaking down takes place is quite unwarranted. These statements do not apply to the mucous glands of the Ophidia, since in many of these animals the breaking down of the cells is certainly very extensive. One cannot but be convinced

* These cells have been recently stated by Krause ("Beiträge zur Histologie der Speicheldrüsen," Archiv f. mikr. Anat., Bd. xlix. 1897) to be sometimes albumen-forming in the submaxillary glands of vertebrates.

that Heidenhain's views on this point* are partially † correct so far as the mucous glands of the Ophidia are concerned, otherwise it would be impossible for a gland reduced to the condition of that of fig. 10 to regain with requisite expediency its normal structure. Another figure (fig. 6), taken from the superior labial gland of *Distira cyanocincta* (one of the Hydrophiinæ) after secretion, exhibits an alveolus with a lumen enclosed by an epithelium consisting of one layer of cells, and although the *proliferating cells* are abundantly present, the condition of affairs is more comparable to that found amongst the unicellular glands, no conspicuous disorganization of the mucus-secreting cells having taken place during secretion. Another point of structure is also exhibited by this same figure, viz., that in certain portions of the labial glands of these animals the supporting connective tissue framework is reduced to a minimum.

The ducts of these glands I have previously considered ‡, and I find them to be of a much smaller diameter than the measurements given by Niemann §.

Good results were obtained with the following stains:—Hæmatoxylin, Hæmalum, Ehrlich-Biondi, Hæmalum and Safranin, or Dahlia and Eosin.

The Parotid Gland.—This gland, which is well developed in all families of snakes and which becomes the *poison-gland* of the venomous species, varies considerably in structure throughout the Ophidia. It is for the most part a serous (albuminous) salivary gland, secreting in the poisonous forms those albumoses ‖ which appear to be the active agents in snake-poisoning. Its structure in the harmless Colubrine forms is well known, being very similar to that of a mammalian serous gland with more numerous alveolar cells, and it has also been described in the Opisthoglyphous Colubridæ ¶ (in which animals it is often superficially indis-

* *Cfr.* Gray's 'Anatomy,' 13th edit. 1893, p. 890.

† These cells are not "destined to supply the place of" the disorganized mucus-secreting cells, but they give rise by proliferation to others which fulfil this function.

‡ P. Z. S. 1895, pp. 814 & 821.

§ F. Niemann, "Beiträge zur Morphologie und Physiologie der Oberlippendrüsen einiger Ophidier," Archiv für Naturgeschichte, Bd. i. Heft 3 (Berlin, 1892).

‖ C. J. Martin and J. McGarvie Smith, "The Venom of the Australian Black Snake," Proc. Roy. Soc. of N. S. Wales, 1892, p. 262.

¶ P. Z. S. 1895, p. 814.

tinguishable from the superior labial gland), a portion of the gland of *Dryophis prasinus* (after a period of activity) having been figured*. The difference in structure of the parotid in these two classes of Colubrine Snakes is almost inappreciable, whereas the difference between the structure as exhibited in these two groups and that found in the Proteroglyphous Colubridæ (and Viperidæ) is most marked. Fig. 8 represents a portion of the gland of *Heterodon* sp. (one of the Aglyphous Colubridæ) during a period of rest; the cells are fully charged with secretion, the cell-contours and the lumen of the alveoli being almost obliterated. I also figure a few alveoli of the gland of *Dipsas ceylonensis* (one of the Opisthoglyphous Colubridæ), after a period of activity (fig. 5), in which the cell-contours are very distinct and a few marginal cells (*p.c.*) are present; these can only be regarded as young cells destined to effect a replacement of the effete gland-cells. Thus it appears that proliferating cells are not confined to mucous glands, but are present to a smaller extent in serous or albuminous glands, in which the destruction of cells and consequent demand for new ones is not so great.

In the Proteroglyphous Colubrine Snakes the alveoli of the gland are much larger and have a lining epithelium of short columnar cells enclosing a capacious lumen in which the secretion is stored. The grosser structure as found in *Naja haje* has been well described by Emery †, and also by Martin ‡ in *Pseudechis porphyriacus*; and I find precisely the same type of structure in *Bungarus ceylonensis*, *Elaps corallinus*, *Petrodymon cucullatum*, and *Brachysoma diadema*. The supporting framework of inter-alveolar connective tissue varies in amount in different species, but in all cases it is developed to a greater extent in the centre of the gland in the region of the forwardly converging ducts. The poison-duct, which is longitudinally folded for the greater part of its course, has opening into it, throughout its length, a series of small glands which completely surround it, and Emery's supposition that in *Naja haje* these small lobules (which he terms "Schleimdrüsen?") are mucous

* *L. c.* pl. xliv. fig. 17.

† Emery, Carlo: "Ueber den feineren Bau der Giftdrüse der *Naja haje*," Archiv für mikr. Anat. 1875, pp. 561–568, t. xxxiii.

‡ C. J. Martin, "Snakes, Snake Poisons and Snake Bites," Hermes Med. Suppl. Journ. Sydney Univ. Med. Soc., Dec. 1895.

glands, I can fully confirm for those genera that I have examined. These lobules are difficult to stain, and the alveoli and cells have a different structure to the rest of the gland.

Certain peculiarities are to be found in the *poison-glands* of the Marine Snakes (Hydrophiinæ), some of which I have already described *. The inter-alveolar connective tissue is extensively developed, this being very noticeable in *Enhydris Hardwickii*; and *Platurus fasciatus* is conspicuous for the small size of the external alveoli, especially at the posterior end of the gland. Fig. 7 represents a portion of four alveoli from the gland of *Distira cyanocincta*, after secretion. The duct, in this group of snakes, is also remarkable for the convoluted course taken by its terminal portion. Small lobules are found arranged round its course as in the other Proteroglyphous Colubridæ; and in *Platurus fasciatus* these glands are reduced almost to single alveoli with a lining epithelium like that of the poison-gland itself; but in *Distira cyanocincta* and *Hydrus platurus* they are more conspicuously developed, a few of them in the latter half of the course of the duct ultimately becoming mucus-secreting. Towards the termination of the duct, the cells of its own lining epithelium also become mucus-secreting in the above two species and possibly in others; this has been shown to be normal in the ducts of the parotid and labial glands of the Opisthoglyphous Colubridæ, but in the Crotalidæ the lining epithelium is a pavement one †. Moreover, as the epithelium of the duct of the submandibular poison-gland of the Saurian reptile *Heloderma suspectum* has been shown by Holm ‡ to have no secretory function, it would appear that this function is confined to the salivary (and poison) ducts of some of the Ophidia. *Thus in the Ophidia are to be found the only animals in which a considerable admixture of mucus is present in the parotid saliva, this mucus being derived in all cases from some of the epithelial cells of the duct and sometimes from special accessory mucous alveoli also.*

The presence of mucous alveoli in the parotid gland and the conspicuous admixture of mucus in the parotid secretion, more especially of Elapine Colubrine Snakes, may perhaps present an analogy to the condition in the submaxillary gland of many

* P. Z. S. 1895, p. 821.

† S. Weir Mitchell, in Smithson. Contrib. Knowl. vol. xii. 1860, p. 13.

‡ Dr. J. F. Holm, "Some Notes on the Histology of the Poison-glands of *Heloderma suspectum*," Anatomischer Anzeiger, Band xiii. Nr. 3, 1897, p. 84.

mammalia *. It is also a noticeable feature that in those animals in which this mixed type of structure is most marked, whether it is in the parotid or in the submaxillary gland, the mucous alveoli are restricted to one large or many small distinct lobules close to the exit of the duct.

The following stains were found useful in making preparations of this gland:—borax carmine, alum carmine, Ehrlich-Biondi, hæmatoxylin and safranin, safranin and orange, eosin and dahlia, carmine alum and bleu de Lyon, and fuchsin and bleu de Lyon.

The Harderian Gland.—This gland is developed to a large degree in most snakes and is the most inconstant of all the glands of the head in the extent of its development, since it varies from the condition of a mere strip of glandular tissue present in *Dryophis* to that of the bulky gland of *Homalopsis*, *Enhydris*, or *Platurus*. In all the snakes examined it has been found to be a typical albuminous gland with much smaller alveoli than those of the parotid.

The Sublingual Gland †.—Immediately beneath the posterior part of the sheath of the tongue is a large gland which pours its secretion into the sheath of the latter structure, thus acting as an accessory (lubricating) agent to facilitate rapid protrusion. I can find but one previous mention of this gland, and that by Minot ‡, who remarks:—"Underneath the sheath is a very large gland, which I have seen in *Eutænia* only. I overlooked it at first and cannot therefore say whether it occurs in *Ancistrodon* or *Crotalus*. As far as I am aware no similar glands have been previously noticed in the Ophidia." I have noticed it in *Philodryas Schottii* and *Dipsas ceylonensis*, and it is most probably present in many other snakes, having, as Minot remarks, been overlooked in the past.

* N. Loewenthal, "Zur Kenntnis der Glandula submaxillaris einiger Säugetiere," Anat. Anzeiger, Band ix. (1894) p. 223.

† Professor Howes has called my attention to the fact that Bisogni has recently described as occurring in non-venomous snakes (Anat. Anz. Bd. xiii. Nr. 18), a 'sous-lingual' glandular group consisting of three glands; these do not appear to me, however, to have any relation with the sublingual gland under consideration.

Cfr. also Bisogni, "Persistenza di una nuova glandula nel genere *Vipera*," Anat. Anzeig. Bd. xiii. Nr. 18 (June 1897).

‡ C. S. Minot, "Studies on the Tongue of Reptiles and Birds," Anniv. Mem. Bost. Soc. Nat. Hist. 1880.

It is a serous gland with rather small alveoli and opens by numerous ducts into the sheath of the tongue; these ducts are lined by a short columnar epithelium and have a capacious lumen. Those specimens in which the gland was observed were in an insufficient state of preservation, and for this reason its detailed structure could not be made out with precision.

From its position I should say it is homologous with the sublingual salivary gland of other vertebrates.

The Succession of the Teeth.

In a paper "On the Development and Succession of the Poison-fangs of Snakes" *, C. S. Tomes remarks (p. 380):—"I believe that the development of poison-fangs in two parallel series would be found to be the rule, if indeed it be not universal, in Viperine poisonous snakes." Also: "The region where teeth are being developed in a *Colubrine* venomous snake, the Indian Cobra, is strikingly different. There is no double series, but the successional teeth are being disposed in a single series, just like the teeth of a harmless snake, or the mandibular or pterygoid teeth of a poisonous snake."

In the only Colubrine venomous snake in which I have studied the successional development of the poison-fangs, viz. *Bungarus ceylonensis*, I find them to be developed not as in the allied Cobra, but, strange to say, in two parallel series as in the viperine snakes. The germs, seven in number, become alternate as they reach maturity.

In *Platurus*, the genus of marine snakes having the most specialized maxilla †, the development is in a linear series behind each of the poison-fangs. The germs, eleven in number, present in these two parallel series, alternate with each other quite as markedly as those of *Bungarus*, and it appears to me that one of the functional poison-fangs is always more firmly ankylosed to the maxilla than the other.

In a letter dated Feb. 11th, 1897, Mr. C. S. Tomes has suggested what appeared to him (and also appears to me) to be the true explanation of the double chain of successional teeth engaged in keeping the Viperine snake ‡ supplied with one

* Phil. Trans. 1876, vol. 166, pt. 2.

† *Cfr.* P. Z. S. 1895, pl. xlvi. figs. 11 & 12.

‡ And also some Proteroglyphous Colubrine Snakes; certainly *Bungarus*, and probably many others.

functional poison-tooth. The maxilla in the Viperidæ is certainly more specialized than that in any other group of the Ophidia, both with regard to its extreme shortness and the nature of the poison-teeth, intermediate conditions being exhibited by the marine snakes *Enhydris* and *Platurus* *. In the latter genera there are two adult functional poison-fangs present side by side at the anterior extremity of the maxilla, developed more or less simultaneously †, and it would appear that in the evolution of the Viperine forms these teeth, specialized as in the above-mentioned marine snakes, were originally present, but that after they had become placed side by side and the maxilla shortened to the utmost, their development became no longer simultaneous, but strictly alternate ‡.

The Relation of the Poison-duct to the Teeth.

The method by which the poison-duct communicates with the groove of the poison-fang is well known, viz., by means of the cavity surrounding the base of the tooth and enclosed by the muscular folds which constitute the proximal portion of the vagina dentis; but even so recently as 1892, the communication has been described and figured as effected by a fine hair-like duct supposed to enter the basal opening of the groove itself §. For many reasons this would obviously be an inconvenient arrangement, since the duct would require a new terminal portion for each new tooth, whereas with the existing arrangement of folds round the base of the tooth, injury or loss of the latter does not in any way affect the apparatus for the transmission of the secretion to the tooth. Another advantage in there being no direct communication between the duct and the basal opening of the groove, lies in the fact that the new tooth does not occupy exactly the same position as the old one by reason of the development taking place alternately from two parallel series.

The sphincter which occurs near the termination of the duct

* *Cf.* Boulenger, 'Fauna of British India: Rept. & Batrachia,' p. 394.

† Each is developed from a single series of successional teeth, and as two adult *fixed* teeth are not always present at the same time the development is not exactly simultaneous, but very slightly alternate.

‡ This development has been wholly misunderstood by S. Weir Mitchell, "Researches upon the Venom of the Rattlesnake," Smithson. Contrib. Knowl. vol. xii. (1860), pp. 18, 19.

§ F. Niemann, *l. c.*

in the Crotalidæ * appears to be absent from the Proteroglyphous Colubridæ, but it seems probable that it has a representative in those cushions of non-striated muscle-fibres present at the base of the fangs in the Hydrophiinæ †, through the slit between which the secretion has to pass.

EXPLANATION OF THE PLATES.

Plate 34.

Fig. 1. Portion of the buccal epithelium of *Dryophis mycterizans*, showing the unicellular glands and the striated free border of the cells. × 520 ‡.

2. Portion of the buccal epithelium of *Bungarus ceylonensis*. × 520 ‡.
3. Buccal epithelium of *Bungarus ceylonensis*, viewed from the surface. × 520.
4. Epithelium towards the edge of the mouth of *Enhydris Hardwickii*. × 520.
5. A few alveoli of the parotid gland of *Dipsas ceylonensis*. × 400.
6. An alveolus of the superior labial gland of *Distira cyanocincta*. × 500.
7. Portion of four alveoli of the parotid gland of *Distira cyanocincta*. × 520.
8. A few alveoli of the parotid gland of *Heterodon* sp., in the resting state. × 520.

Plate 35.

Fig. 9. A few alveoli of the superior labial gland of *Heterodon* sp., in the resting state. × 520.

10. A portion of the superior labial gland of *Dipsas ceylonensis*, in active secretion. × 520.

b.v. Small blood-vessels.
c.t. Alveolar connective tissue.
ep.gl., *ep.'gl.'* } Unicellular glands of buccal epithelium.
p.c. 'Marginal cells,' which replace effete gland-cells by proliferation.

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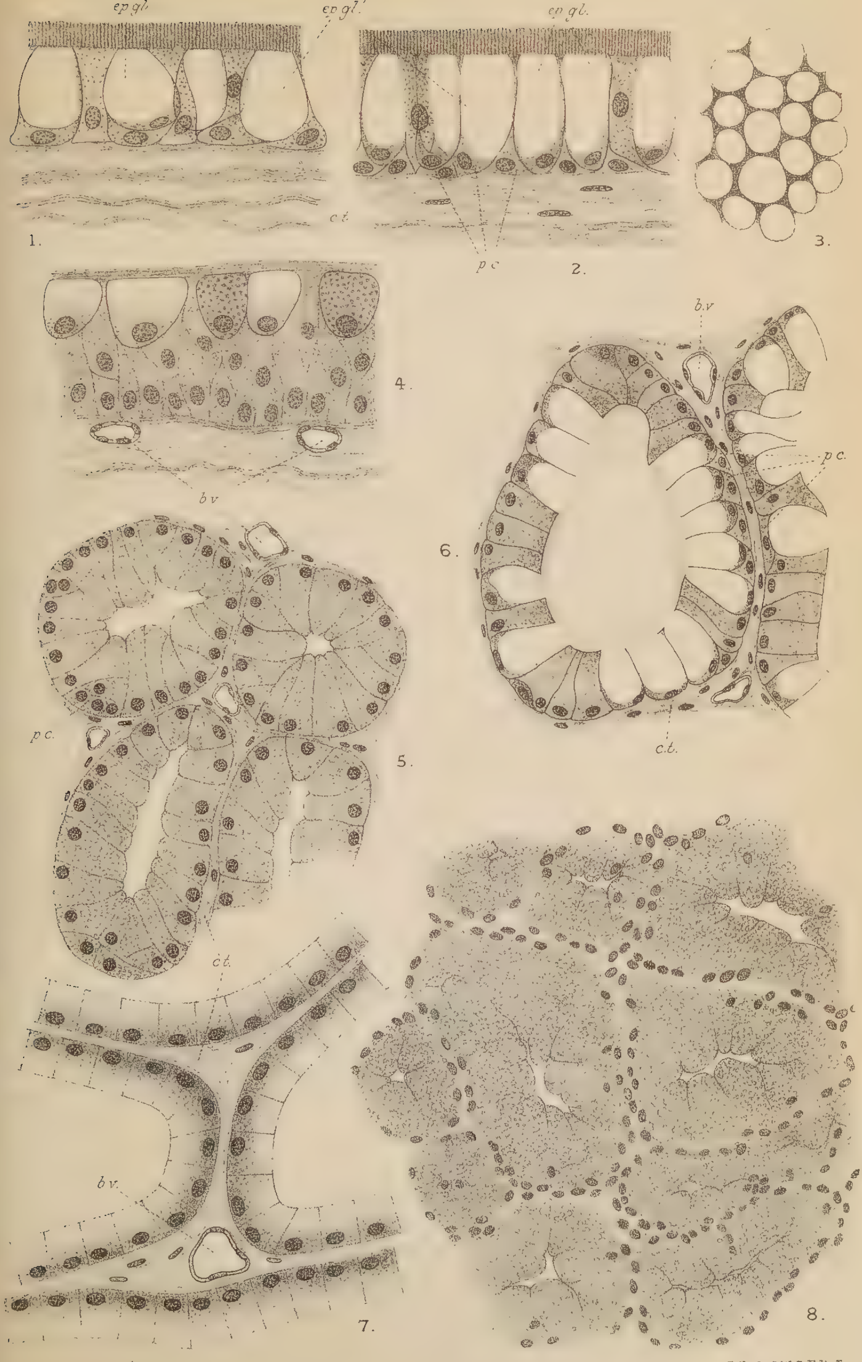
* S. Weir Mitchell, *l. c.* p. 15, fig. 6 B.
† *Cfr.* P. Z. S. 1895, p. 821, pl. xlvi. figs. 13 & 14.
‡ The two sections here figured were cut especially for the study of the teeth and consequently more than one layer of cells thick. It was therefore not possible to decide whether the striated free border figured as overlying the mouths the goblet-cells really belonged to them or to adjacent cells.



G. S. West ad nat. del.

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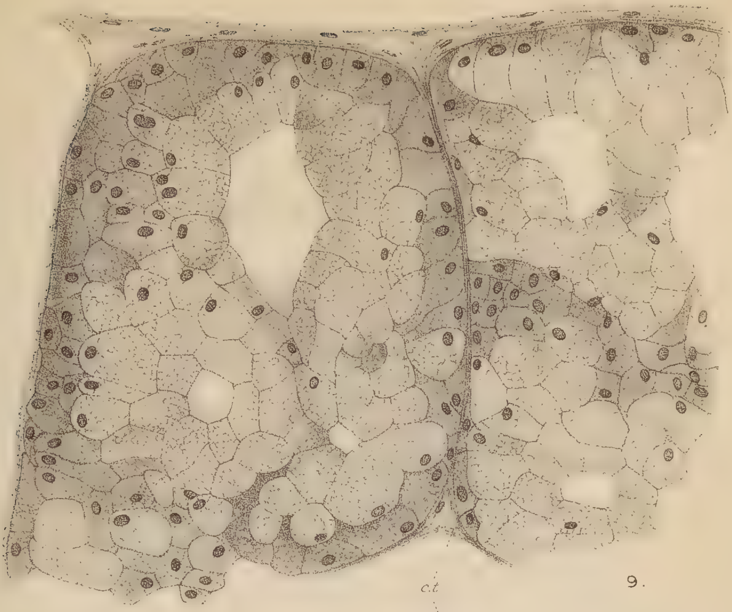
GLANDS OF COLUBRIDÆ.



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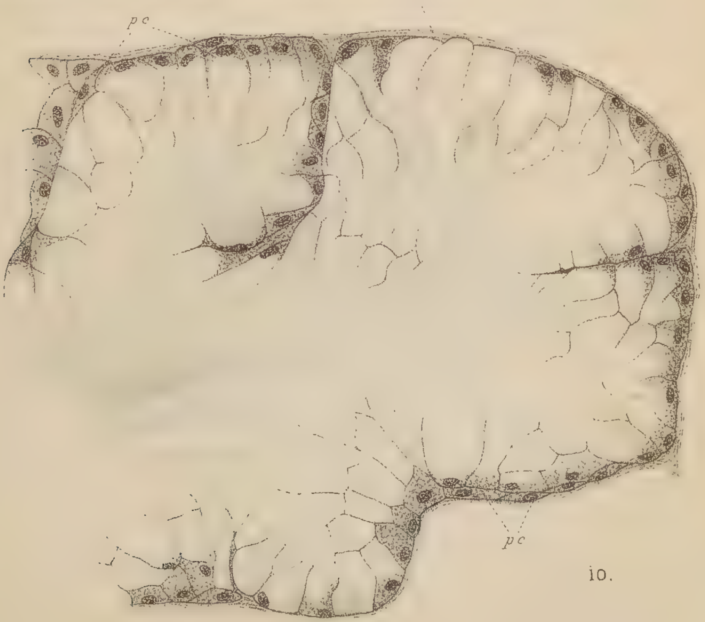

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G. S. West ad nat. del.

F. Huth, Lith^{r} Edin^{r}

GLANDS OF COLUBRIDÆ.

Preliminary Account of some New-Zealand Actiniaria.

By H. FARQUHAR.*

[Read 7th April, 1898.]

(PLATE 36.)

A FEW years back I began to collect Sea-anemones and make notes on their habits and distribution, and I had hoped before this to have prepared full descriptions with sectional figures of the species found in the neighbourhood of Wellington. Circumstances, however, have prevented me doing so up to the present; and as it may be some time before I am able to prepare a full report, I give here a preliminary account of a few of the species the position of which I have been able to determine with certainty.

It is evident that we have here in New Zealand a rich and extremely interesting Actiniarian fauna. The species appear to be all endemic, while the genera are for the most part widely diffused, and I may mention here one or two points which seem to me to present themselves for investigation. The species known to me appear to fall naturally into three classes as to their geographical distribution:—(1) Species which are extremely abundant at the stations where they occur, but confined to a very limited area of distribution, such as *Actinia tenebrosa*, and probably *Halcampactis mirabilis*, *Corynactis Haddoni*, and *Corynactis mollis*; (2) species which are abundant at the stations where they occur and have a comparatively large area of distribution, such as *Anemonia olivacea*, Hutton, *Phymactis inconspicua*, Hutton, and *Gregoria albocinctus*, Hutton; (3) species which are not abundant at the stations where they occur, but which have a comparatively wide area of distribution, such as *Oulactis plicatus*, Hutton, and *Actinia ? Thomsoni* †, Coughtrey. A great deal of work will have to be done before it can even be

* Communicated by T. W. KIRK, F.L.S., F.R.M.S., Government Biologist, Department of Agriculture, New Zealand.

† This species, which is not uncommon in the neighbourhood of Wellington, does not belong to the genus *Actinia*. It will probably form the type of a new genus of the family Antheadæ, having a weak sphincter muscle, no marginal spherules, the body-wall smooth and divided into two parts, scapus and capitulum. It was described by Dr. Coughtrey in the Trans. N. Z. Inst. vol. vii. p. 280. Descriptions of Professor Hutton's species mentioned above may be found in the Trans. N. Z. Inst. vol. xi. p. 311.

decided whether what I have observed in regard to the distribution of the Actinians in the neighbourhood of Wellington obtains throughout New Zealand. If it be so, the explanation may possibly be found in the mode of reproduction of the several species. In some species the young are retained in the body of the parent till metamorphosis has taken place. In others it may be that some of the young are developed within the parent, while others are liberated when they are free-swimming, ciliated embryos. And in other species the young may all be liberated in the form of free-swimming embryos, when they are widely dispersed by the currents, and thus these last are never found in great abundance at any one particular station.

There appear to be two distinct littoral marine faunas in New Zealand—a northern and a southern. Mr. H. B. Kirk, who, as Inspector of Native Schools, often travels around our coasts from the North Cape to Stewart Island, informs me that the assemblage of marine animals to the north of East Cape presents a striking difference to that on our southern shores—the Actinian faunas being especially distinct.

The new species *Halcampactis mirabilis* is an exceedingly interesting form, since by its strange combination of characters it forms a link between the two families *Sagartidæ* and *Halcampidæ*, which have hitherto been widely separated by systematists.

I desire to express my thanks to Professor Hutton and Mr. H. B. Kirk for their kind assistance.

EDWARDSIA ELEGANS, n. sp. (Pl. 36. figs. 1, 2.)

Body long and vermiform, very variable, usually clavate, divided into physa, scapus, and capitulum. Physa spherical, small, smooth, and delicate, completely retractile, without a terminal pore, but furnished with minute suckers. Scapus in three distinct parts—the lower third is covered with a rough epidermis, then follows a part, occupying nearly two-thirds of the scapus, clothed with very thin, smooth epidermis, succeeded by a short length without epidermis, smooth, delicate and barrel-shaped when expanded. Body-wall transversely wrinkled when contracted, traversed by eight shallow, indistinct, longitudinal grooves, except on the lower rough part, where they cannot be seen. Capitulum short, smooth, and delicate. Not only the disc and capitulum but also the naked part of the scapus, and the part below this clothed with smooth epidermis, are retractile.

Tentacles long, thin, cylindrical, pointed, equal, bicyclic, 16 (8+8). Mouth elongate, raised on a prominent cone. Œsophagus strongly ribbed. Physa pellucid white. The lower rough part of the scapus rather dull chestnut-brown, the part clothed with smooth epidermis pale yellowish orange, and the naked part transparent pale reddish orange, with eight fine, double, longitudinal, bright red lines. Capitulum madder-brown or orange, with eight opaque white lenticular figures, which alternate with eight longitudinal, double, white lines. Tentacles pellucid white, tipped with opaque yellowish white. Disc pale madder-brown, with eight radiating white lines, and white round the bases of the tentacles. Œsophagus orange or white. Length of body expanded about 75 mm.; length of capitulum 3 mm., diameter of capitulum 2·4 mm.; length of tentacles 6 mm.

Hab. Cook Strait, in the neighbourhood of Wellington; not uncommon on the undersides of stones, just below low-water mark.

The first specimen of this beautiful species was placed in my hands by Mr. H. B. Kirk, 25th May, 1894.

EDWARDSIA NEOZELANICA, n. sp. (Pl. 36. fig. 3.)

Body long and vermiform, very variable; divided into three distinct parts, physa, scapus, and capitulum. Physa rather large, exceeding the scapus in diameter, bladder-like, furnished with exceedingly minute suckers, retractile. Scapus long and cylindrical, invested with a very thin, rather rough epidermis, except a very short length above, which is naked; traversed by eight shallow, longitudinal furrows, which correspond to the insertions of the mesenteries. Capitulum short, delicate, and smooth. Tentacles very thin, long, cylindrical, equal, pointed, bicyclic, 16 to 24 (usually 16), the tips usually recurved. Disc, capitulum, and upper part of scapus retractile. Length of body expanded about 43 mm.; diameter of physa 3·2 mm.; diameter of scapus 2·5 mm.; length of tentacles 3·7 mm. Physa pellucid white, with eight opaque white longitudinal lines. Scapus very pale transparent orange, becoming buff or bright orange near the capitulum, traversed by eight whitish longitudinal lines. Capitulum, disc, and tentacles uniform pellucid white or pinkish white, without any markings.

Hab. Lyall Bay and Ohiro Bay, on the undersides of stones and roots of *Lessonia*; fairly abundant.

HALCAMPACTIS, n. g.

Hexamerous actinians with acontia; aboral end of the body rounded, without pedal disc; body divided into three parts, capitulum, scapus, and physa; capitulum retractile; body furnished with suckers; no sharply-defined circular muscle; six pairs of strongly-developed, perfect mesenteries; secondary mesenteries probably always present; tentacles few, conico-cylindrical.

HALCAMPACTIS MIRABILIS, n. sp. (Pl. 36. figs. 4–6.)

Body cylindro-clavate, exceedingly variable, divided into capitulum, scapus, and physa; body-wall smooth in expansion, transversely and longitudinally wrinkled when contracted; studded with exceedingly minute suckers. Disc flat, with slight corrugations from the bases of the inner tentacles to the mouth; radii distinct. Mouth linear, not prominent, but often gaping. Throat strongly ribbed. Tentacles cylindrical, with rounded extremities, bicyclic, 24 (12 + 12), those within slightly larger than those without, often recurved in extension. Acontia emitted rarely, and by the mouth only. Scapus and physa brownish red or yellowish red, rarely dusky brown; capitulum pale yellow or crimson. Disc buff or pale yellow, with twelve patches of madder-brown round the mouth between the radii, and sometimes sulphur-yellow spots near the bases of the tentacles. Tentacles pale yellow, with four or five dark brown or sulphur-yellow spots formed by pigment-cells which line the interior tube; when the tentacles are partly contracted, this colour appears to line the whole interior. Œsophagus rich orange. Length of physa and scapus together about 26 mm.; diameter of physa 7 mm.; diameter of scapus about 4 mm.; length of capitulum 2 mm.; diameter of disc 4·5 mm.; length of tentacles 3 mm.

Hab. Ohiro Bay and adjacent coast, near Wellington; on roots of *Lessonia* and undersides of stones, below low-water mark; abundant.

This species has no well-defined line between the scapus and bladder-like physa; the capitulum, however, is better defined, being separated from the scapus by a slight constriction and usually by an irregular band of dark colour. A constriction

often passes down the body, when the aboral end assumes the appearance of a terminal orifice, though no such orifice really exists. So far as I can make out, there are no perforations in any part of the body-wall. The disc and capitulum can be completely and quickly invected, when the body becomes clavate or fusiform, with six prominent crest-like ridges above, the crenations between these corresponding with the insertions of the six pairs of perfect mesenteries. The tentacles are transversely wrinkled when contracted, and they can be reduced to mere wart-like processes. The six alternate tentacles of the inner cycle, which spring from the endocœles of the perfect mesenteries, are frequently more prominent than the other six which spring from the endocœles of the imperfect mesenteries, being held more forward and upright. The tentacles of the outer cycle spring from the exocœles. The body is clothed with a thin, rough, greyish cuticle, which is thrown off in captivity. The acontia consist of a tough, transparent, homogeneous, fine, thread-like axial band surrounded by granular tissue composed of ciliated cells, among which the nematocysts lie packed closely together with their outer ends slightly directed towards the free end of acontia. The acontia are 0·1 mm. in diameter, and the nematocysts of the acontia 0·072 mm. in length. When the body-wall is ruptured the long, white, thread-like acontia (with free ends) stream forth freely. The nematocysts are then discharged and the axial band only withdrawn. Sections through the body show six pairs of perfect mesenteries (macrosepta) bearing strongly developed, circumscribed retractor muscles, characteristic of the *Halcampidæ*. Six pairs of imperfect mesenteries (microsepta) alternate with the six pairs of perfect mesenteries. The mesenteries and acontia can be clearly seen with a lens through the thin, transparent body-wall of an expanded individual.

I am indebted to my friend Mr. H. B. Kirk for the first specimens of this extremely interesting little species. Two very fine specimens were discovered by him at Ohiro Bay, while collecting calcareous sponges, and were placed in my hands 26th Sept., 1893. One of these was conspicuous in having a beautiful bright crimson capitulum, the colour shading off on the scapus.

The young of this species are not parasitic like the young of *Halcampa*. I have often found full-grown individuals with

numerous young ones grouped around them, evidently as they had attached themselves round the parent when born.

Corynactis Haddoni, n. sp.

Base exceeding the column, often widely extended, sometimes with an irregular wavy margin. Column exceedingly variable, cylindrical or pillar-shaped, often contracted in the middle, sometimes vase-shaped; surface smooth, without papillæ and without suckers; transversely wrinkled when contracted; substance firmly fleshly. Disc often greatly exceeding the column, circular, usually concave in expansion, the edge of the disc and the peripheral tentacles overhanging the column; radii distinct. Mouth linear, prominent, sometimes assuming a circular conical form. Œsophagus strongly ribbed. Tentacles in two series: a series of marginal principal tentacles, and a series of intermediate accessory tentacles. The principal tentacles are arranged in two cycles, with about 40 in each cycle. All the tentacles of the same cycle are equal to one another; those of the inner cycle when fully extended are about three times as long as those of the outer cycle. The short principal tentacles on the periphery of the disc alternate with the longer ones within, and form radial series with the intermediate accessory tentacles. Each radial series consists of a principal tentacle on the periphery of the disc and from two to four accessory intermediate tentacles. These radial series of tentacles correspond to alternate mesenterial chambers, apparently the exocœles. The tentacles forming radial series decrease in size from without inwards. The shafts of the tentacles are cylindrical, tapering, with a narrow smooth neck just below the knob, succeeded by a region covered with minute ridges and papillæ, becoming smooth again at the base. In contraction the tentacles are transversely wrinkled. The knobs of the tentacles are very rich in nematocysts, adhering to anything with which they may come into contact. Although not very sensitive the tentacles can be completely retracted, the sphincter muscle evidently being fairly well developed. The colour of this species is very variable. I have been able to distinguish the following seven varieties:—

(1) Column deep reddish orange, passing into chocolate-brown above, frequently with a greyish or brownish-grey tinge near the base. Disc deep madder- or chocolate-brown, with an undefined purplish band about halfway between the mouth and

the periphery of the disc. The disc is variegated with irregular patches of opaque white, sometimes with a bluish tinge. Œsophagus reddish orange. The long primary tentacles brown, becoming transparent at the base; all the other tentacles pellucid white below, and brown or yellowish brown above; knobs of all the tentacles brown. Abundant.

(2) Column lemon-yellow, passing into white or pinkish white below, with fine opaque white vertical lines, which mark the insertions of the mesenteries. Disc lemon-yellow, sometimes with a greenish tinge towards the periphery. Tentacles pale yellowish pink. Rare.

(3) The whole animal a beautiful, uniform rose-pink; sometimes the tentacles are white. Not uncommon.

(4) Column brownish pink, passing into light crimson above. Disc pale pink or very pale crimson. Principal tentacles brown with purple knobs; accessory tentacles white below, passing into brown above, and white knobs, sometimes with a purplish tinge. Rare.

(5) Column pellucid white, with a pale pinkish tinge below; fine opaque white lines mark the insertions of the mesenteries. Disc beautiful pellucid pale sea-green. Tentacles pellucid white with a faint pinkish tinge. Very rare.

(6) Column madder-brown, darker above. Disc pale madder-brown. Shafts of tentacles light brown below, becoming deep chocolate-brown above, knobs white; œsophagus orange. Not uncommon.

(7) Column chocolate-brown. Disc dark chocolate-brown near the margin, and bright green between the tentacles and the mouth. Shafts of principal tentacles brown, with a white band round the base, knobs pale crimson. Uncommon.

The height of this species is about 20 mm.; diameter of column about 6 mm.; diameter of disc 12 mm.; diameter of base about 10 mm.; length of longest tentacles 5 mm.

Hab. Lyall Bay, Island Bay, and Ohiro Bay, on rocks just below low-water mark.

This exceedingly beautiful species was known to Mr. H. B. Kirk long before he pointed it out to me about four years ago. It adheres so strongly that it is difficult to detach a specimen without tearing the base. It evidently increases by budding from the base, as clusters of specimens are often found organically attached to one another at their bases.

CORYNACTIS MOLLIS, n. sp.

This species is similar in form and external appearance to *C. Haddoni*. Column pale reddish brown, becoming darker above. Disc deep reddish brown. Shafts of principal tentacles brown; knobs of the long principal tentacles bright purplish pink, those of the shorter ones on the periphery of the disc white or pinkish white; accessory tentacles white below, becoming brown above with pale pinkish knobs.

Until quite recently I considered that this form was a well-marked variety of *C. Haddoni*. I am now convinced, however, that it is a distinct species. It never varies in colour, except that the colour of those specimens not so much exposed to the light is paler than that of others. It is never found on rocks, but only on *Lessonia*, where it is extremely abundant. The substance of the body is not so firm and more delicate than in *C. Haddoni*. When the anatomy of the two species is worked out other differences will probably be discovered.

Hab. On the stems and roots of *Lessonia*, just below low-water mark, in the neighbourhood of Wellington.

This species and an undescribed brown Sagartian, which is also extremely abundant on *Lessonia* in the same locality, appear to form the principal food of the Butter-fish (*Coridodax pullus*), one of our finest food-fishes. Sir James Hector has pointed out that the curiously formed teeth of this fish are well adapted for scraping zoophytes from seaweed ('Notes on the Edible Fishes of New Zealand,' p. 115).

CORYNACTIS GRACILIS, n. sp.

Base exceeding the column. Column cylindrical, very variable, surface smooth. Disc circular, often convex, exceeding the column in expansion. Mouth linear, prominent. Œsophagus ribbed. This species is very similar to *C. Haddoni*; the form and arrangement of the tentacles are the same; the tentacles are, however, less numerous, there being about 28 in each cycle. The shafts of the principal tentacles of the inner cycle are not so long as in *C. Haddoni*, being only slightly longer than those of the outer cycle. The whole animal is pellucid yellowish white, except the knobs of the tentacles, which are magenta.

This appears to be rather a rare form; I have only found a few specimens on *Lessonia* at Ohiro Bay near Wellington. It was first discovered by Mr. H. B. Kirk. It is a smaller species than

C. Haddoni (the height being about 13 mm., and the diameter of the disc about 8 mm.), less variable in form, and, unlike that species, it appears not to increase by budding, all the specimens which have been found being solitary.

ACTINIA TENEBROSA, n. sp.

Column cylindrical, short; body-wall smooth, without warts, extending beyond the disc and forming a well-developed collar, within which the marginal spherules lie hidden; marginal spherules numerous, bluish white; tentacles conical, in three indistinct, crowded rows. Height of column about 27 mm.; diameter of disc about 40 mm.; length of tentacles about 15 mm.

Hab. On rocks, just above high-water mark, in the neighbourhood of Wellington; abundant. Mr. T. M. Grant informs me that it also occurs freely in Queen Charlotte Sound.

This species is a good example of the effect of light on the colour of animals. Full-grown individuals in situations well exposed to the rays of the sun have the column greenish or brownish black, and the disc and tentacles dusky crimson, while those on the undersides of overhanging stones are reddish brown or crimson, the depth of colour varying according to the amount of light which reaches them. Specimens on the vertical sides of rocks (their favourite habitat) often have a patch of reddish brown on the side turned away from the light. I found a specimen under a large stone which had evidently never been in the light: the whole animal was yellowish white with a slightly greenish tinge.

This is a fine species for the investigation of the development of Actinians, for large specimens usually have a number of young ones within them in different stages of development. The young are retained in the body of the parent till they attain a considerable size.

This is the southern representative of the European species *Actinia equina*. It forms another extremely interesting example of the law discovered by the late Prof. Edward Forbes, the great pioneer of the distribution of marine animals, that "similar species, to which the term *representative* is mutually applied, appear in areas distant from each other, but under the influence of similar physical conditions" (Nat. Hist. of the European Seas, p. 8). It appears that this law (if such it may be called) was also

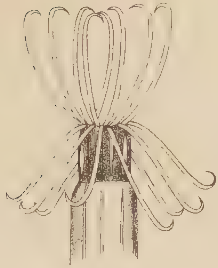
operative in former geological times. The late Rev. Tenison-Woods, when studying the Tertiary fauna of New Zealand, found a *Fasciculipora* very nearly allied to a species of Bryozoan from the Lower Pliocene of Europe. It was, he considers, "a fact of more than ordinary interest in natural science that two such characteristic and closely allied organisms should flourish at the same epoch, in such remote seas as those of Britain and New Zealand. The differences between the fossils were so small that if they were found in the same beds they would be regarded as mere varieties." (Proc. Linn. Soc. N. S. W. vol. v. p. 283, 1881.)

I believe that most interesting and valuable results (results that would perhaps modify the views held by many as to the origin of species) would be obtained if a naturalist, thoroughly conversant with the literature and who has access to one of the great natural history libraries in England, were to collect all the information which has been recorded relating to representative species found in Europe, Australia, and New Zealand, and work out the affinities of the faunas, both terrestrial and marine, of these regions. Unfortunately this could not be done fully at present, for some of the groups, such as the Annelids, Sponges, Tunicates, Infusoria, and Insects, have not yet been thoroughly worked up in New Zealand; and some of those who have attempted to describe species have done so insufficiently, and without giving their relations and affinities.

EXPLANATION OF PLATE 36.

Fig. 1. *Edwardsia elegans*, with disc and capitulum invected. Nat. size.
2. " " Capitulum and tentacles. × 3.
3. *Edwardsia neozelanica*. Nat. size.
4. *Halcampactis mirabilis*. Nat. size.
5. " " Nematocysts of the acontia. × 280.
6. " " Disc and tentacles. × 3.

1



2 ×3

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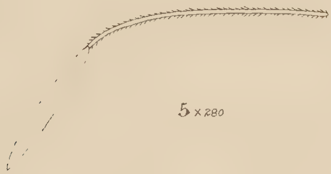

5 ×280

6 ×3

H. Farquhar del.
Parker & Percy lith.
Geo West & Sons imp.

NEW ZEALAND ACTINIARIA.

The Thymus in the Marsupials. By JAMES JOHNSTONE, Fisheries Assistant, University College, Liverpool *.

[Read 21st April, 1898.]

(PLATES 37-39.)

THE investigation which forms the subject of this paper was pursued at the Royal College of Science, London, at the suggestion of my former teacher, Prof. G. B. Howes, F.R.S., to whom I am deeply indebted for much valuable assistance and for placing at my disposal the adult material upon which I report. I am also grateful to Mr. M. F. Woodward, who helped me greatly, and gave me the pouch-specimens referred to below. In addition I have to thank Prof. Symington, of Queen's College, Belfast, for allowing me to read the manuscript of his paper (1) on this subject, lately published in the 'Journal of Anatomy and Physiology,' which was in the printer's hands while my work was in progress.

I have examined the following forms :—*Didelphys pusilla*, *Thylacinus*, *Dasyurus viverrinus*, *Antechinomys lanigera*, *Perameles Gunni*, *Trichosurus vulpecula*, *Cuscus orientalis*, *Petaurus*, and *Phascolarctus cinereus*, all adult specimens. I have also cut serial sections of pouch-specimens of *Didelphys murina*, *Dasyurus viverrina*, *Myrmecobius fasciatus*, *Perameles*, *Trichosurus vulpecula*, *Macropus Wilcoxii*, and *Macropus Eugenii*. It is unnecessary to recapitulate the history of our knowledge of this subject, since that has been so recently done by Prof. Symington in the paper mentioned, except to add that, in addition to the papers referred to by him, there is one by Otto (3) in which the thymus is described in *Didelphys*, *Macropus*, *Petrogale*, and *Hypsiprymnus*. I propose to describe the topographical anatomy of the thymus in genera and species hitherto unexamined, and to record the fresh facts which I have observed.

I. DIDELPHYIDÆ.

Didelphys pusilla. Adult specimen. (Pl. 39. fig. 10.)

The thoracic contents were hardened and sectioned serially. The thymus (*tm.*) was very large and occupied the characteristic position in the upper part of the thorax. A delicate prolongation

* From the Zoological Laboratory, R. Coll. Sci. London. Communicated by Prof. G. B. HOWES, F.R.S., Sec.L.S.

of it extended some little distance upwards along the ventral side of the trachea and then died out. Most of the organ lay posterior to the first rib. It was most massive at about the point of bifurcation of the carotids, and consisted there of six lobes separated by fatty connective tissue. Thence it spread out as a thin sheet posteriorly and laterally, so that in the more posterior sections its extreme lateral edges touched on the one side the trachea, and on the other the œsophagus, dorsal to the pericardium. About halfway between the base and apex of the heart it was reduced to a mere vestige on one side.

In this specimen there were indications of two types of histological structure in the thymus: on the right side there was a lobe almost co-extensive with the rest of the gland, from which it differed in showing a more definite capsule (as a matter of fact no capsule existed in the other lobes of the thymus, which at almost every point was in contact with a layer of fatty connective tissue), no division into cortical and medullary portions, and a very abundant blood-supply, capillaries permeating all its substance.

Didelphys murina.

My only example was a pouch-specimen of about 2·5 centim. in length. Hair was found all over the surface of the body, and ossification had well advanced. The head had been removed, but the most anterior sections showed most of the submaxillary gland and the thyroid. I was unable to observe any indication of a cervical extension of the thymus or of a detached cervical portion. The gland itself lay entirely within the transverse plane passing through the junctions of the first and fourth ribs with the sternum. It was four-lobed, the greatest elongation of the lobes being dorso-ventral. Posteriorly it was reduced to thin lateral sheets lying on the sides of the pericardium.

II. Dasyuridæ.

I have examined four specimens of this family—a full-grown *Dasyurus viverrinus*, a full-grown *Thylacinus*, a mammary fœtus of *Dasyurus*, species indeterminable, and a full-grown specimen of *Antechinomys lanigera*.

Dasyurus viverrinus.

The heart (Pl. 37. fig. 1) was almost entirely surrounded by fat (*f*), two large lateral masses of which extended from its base

along the sides towards the diaphragm, where they formed a thick expanded mass. Similar tissue lay about the bases of the carotids and great veins. In the midst of this fat, and extending from a little above the first rib to about the third, were several masses of tissue (*tm.*) presenting the characters of a thymus. They were much elongated longitudinally. Two lay to the right and one to the left, between the first and second ribs. Two other smaller masses lay approximately medially. All these portions of thymus-tissue were flanked by the fat-masses, which met on the diaphragm with a distinct median furrow between them. The pericardium itself was also found to be fat-laden about the origin of the great vessels. Microscopic examination showed the parts I have termed thymus to possess the structure characteristic of that organ. Fatty degeneration had, however, gone on to a very great extent, and I suspect the gland must have extended much further towards the apex of the heart at an earlier period.

Dasyurus sp. Fœtus; length 7·5 millim.

The head was strongly flexed, and the tissues were in a bad state for detailed histological investigation. The thyroid was a paired body with a well-marked isthmus and consisted of loosely-packed, solid cords of cells. Its greatest length was about 0·5 millim. It lay quite below the lower border of the cricoid cartilage.

The thymus was also a paired body, consisting on either side of a smaller posterior and a larger anterior lobe. These lateral portions at no point approximated closely. They presented the usual characters of embryonic thymus-tissue, small densely-packed cells, staining deeply with carmine. The anterior portions began slightly above the first rib; they were approximately 0·4 millim. in greatest length, and their greatest width was only about 0·02 millim. They occupied the usual position, almost touching the dorsal surface of the sternothyroid muscle and lying between this and the carotids; they were divided into several unequal lobules.

The posterior lobes were in all respects similar in histological structure to the anterior described above. They occupied a position at about the transverse level of the top of the aortic arch. They were situated somewhat wider apart than the anterior lobes, and lay in little cavities as if they had retracted away from the

surrounding tissues. They were about 0·1 millim. in length, and of about the same width as the anterior lobes. There were no connexions between anterior and posterior lobes.

I could find no trace of thymus-tissue in the neck.

Thylacinus. A full-grown specimen: head-length about 21 centim.

The thymus (Pl. 37. fig. 4, *tm.*) lay partly in the neck, but mostly in the thorax. It stretched down to about one-third of the length of the heart from the base of the latter, presenting at the posterior extremity a thin, flattened-out, asymmetrical lobe. Some little distance above the first rib it passed, without any decided transition, into an irregular fat-mass (*f*). It was very irregular in form, and showed in its cervical portion a division into two lobes which were not confluent posteriorly. It was most massive some little distance below the bifurcation of the carotids, and at this point it covered the carotid fork and the origin of the right subclavian artery. Altogether there were in the thymus a pericardiac flattened-out portion; a cervical extension ending about 4 centim. above the first rib, consisting of two paired, closely approximated lobes; and an intermediate portion, elongated in a dorso-ventral direction and somewhat irregular in form. The entire organ, with the exception of the flat pericardial portion, seemed to be compressed laterally in the narrow mediastinal space.

On microscopic examination the ordinary structure of the thymus was seen, except that everywhere the organ was invaded by fat. Here and there the thymus-tissue was reduced to narrow strands of cells ramifying among the fatty connective mass.

The head of this specimen had been cut off, but on examination of it a number of glandular bodies could be seen lying beneath the submaxillary glands. All of these were submitted to microscopic examination, and proved to be ordinary lymph-glands. There was no evidence of a detached cervical thymus.

Myrmecobius fasciatus. Fœtus, 2 centim. long.

The thoracic thymus occupied the ordinary position, and was a paired body, triangular in shape in longitudinal section. The paired halves were not confluent. Marked secondary lobulation had taken place, and the distinction in the lobules of cortical and

medullary portions was very evident. There was no cervical portion as distinct from a thoracic. Paired aggregations of lymphoidal tissue lay without the thorax, external to the pectoralis muscles, and similar small nodules lay in contact with the posterior borders of the submaxillary glands. I am disinclined to regard these as representing detached portions of the thymus.

Antechinomys lanigera.

There was a thoracic thymus consisting of two paired lobes in the usual place, on the base and ventral aspect of the heart. In the neck I could find no thymus. Wedged in between the submaxillary and parotid glands and at their anterior borders there was a very small separate lobe, which on microscopic examination exhibited rather the characters of a lymph-gland than of a true thymus, so that I am disposed to regard it as belonging to the former class of organs.

III. Peramelidæ.

Perameles Gunni. Adult specimen, full-grown.

The thymus (Pl. **37**. fig. 3) was well developed and entirely thoracic. It consisted of two lobes (*tm.*), extending from a little below the first rib to about halfway between the second and third. Opposite the first rib, where the pericardial sac was narrow, the thymus was elongated dorso-ventrally and somewhat massive. Further down it thinned out. The right lobe was thicker than the left, which was very thin and closely applied to the pericardium. There was no external sign of division into secondary lobules. There were no surrounding fat-masses, and except for a slight irruption of fatty tissue the microscopic structure was quite normal.

Perameles Gunni. Fœtus: head-length 1·75 centim. (Pl. **38**. fig. 9.)

There was no cervical thymus present. The thoracic organ (*tm.*) was relatively larger in this specimen than in any other fœtus I have examined. It began at about the anterior limit of the sternum as two massive lobes with much secondary lobulation. At its point of greatest development it measured two-ninths of the dorso-ventral diameter of the thorax at that plane, and two-

sevenths of the lateral diameter. Lower down it formed two thick paired lobes which extended posteriorly to the apex of the heart.

IV. Phalangeridæ.

Trichosurus vulpecula. (Pl. **37**. fig. 2.)

Symington has described the thoracic and cervical portions of the thymus both in the adult and fœtus of this species, and I have little to add to his account. In my youngest specimen, an animal in good condition and measuring 19 centim. in length, the thoracic thymus (*tm.*) consisted of three large lobes, rather above the base of the heart, and a small spindle-shaped body situated on the ventral aspect of the right carotid. The two lateral lobes of the thyroid were joined by a distinct isthmus (*is.*, Pl. **37**. fig. 2), which is generally absent from the thyroid of adult marsupials. Both my other specimens were old, and in them the thymus was reduced to a mere nodule of fatty tissue situated on the origin of the carotids, containing scattered groups of thymus-cells. I have also examined sections of the neck and thorax of a fœtus, and found both thoracic and cervical portions of the thymus as described by Symington.

Cuscus orientalis.

The thoracic thymus (Pl. **37**. fig. 5, *tm.*) lay in my specimen anterior to the first rib (I.) and on the roots of the great vessels (*a.c.′*, *a.c.″*). It consisted of a median mass, undivided into lobes, and sending two prolongations along the ventral sides of the carotids, each terminating in a fine point. I could not make out the presence of a cervical portion, but it is probable that I may have overlooked its existence in this form.

Phascolarctus cinereus.

I had two specimens of this species, each measuring about 20 centim. from the snout to the root of the tail, and therefore rather young. In neither case could I find any thymus. In the mediastinal cavity itself I could detect nothing which might be interpreted as either a rudiment or a vestige of a thymus, and in the neck there were no structures of like nature.

Petaurus breviceps. Full-grown specimen.

The thymus was represented by a mass of tissue lying about

the origin of the great vessels. This mass of tissue was somewhat irregular in shape, and was asymmetrical, lying almost entirely to the left side. I searched for traces of a cervical portion, but was not able to recognize any such structure. Various bodies in the neck having the appearance of adenoid tissue were examined microscopically, but proved to be nothing more than small lymph-glands. The mass lying on the origin of the great vessels was found to be a true thymus.

(In this specimen the innominate artery branched, after springing from the aortic arch, into the left subclavian and a common trunk, which gave origin to the right and left carotids. The right subclavian artery was given off from the right carotid just above the origin of the latter from the common trunk.)

V. Macropodidæ.

I have not examined any adult forms belonging to this family, but I have sectionized a fœtus *Macropus Eugenii* about 21 millim. in length, and of *Macropus Wilcoxii* of about the same length. I have also examined sections cut from a fœtal *Macropus* belonging to Mr. M. F. Woodward, the species of which I am unable to determine.

In *M. Eugenii* the thyroid was represented by a median unpaired, and by lateral paired parts. The thymus consisted of cervical and thoracic portions, which had no connexion with each other. The thoracic portion consisted of two separate portions on each side which lay longitudinally. The cephalic lobes differed notably from the caudal lobes in histological structure.

The Thyroid.

The lateral paired lobes of the thyroid were in their greatest length about 0·45 millim. They were somewhat rounded masses, but rather elongated internally, and lay posterior to the cricoid cartilage of the larynx. In this specimen the long axis of the head formed a right angle with the longitudinal axis of the body, so that the submaxillary gland lay at about the same transverse level as the atlas vertebra. The lateral thyroids lay in this plane, almost touching the submaxillary glands.

The median thyroid lay in the same plane as the lateral lobes, wedged in between the sternothyroid muscles and the trachea. It was only approximately median and unpaired. In its greatest

length it was about 0·15 millim., and in transverse diameter it measured 0·39 millim., so that it was elongated transversely. There was no evidence of a median constriction, and there was a delicate prolongation on its anterior border. In histological character it consisted of short tortuous strings of cells staining less intensely with carmine than those composing the thymus. As a rule these cellular cords contained no lumen, but here and there was a denser aggregation of cells at their periphery. Anastomoses were not frequent. The median lobe lay in a sort of cavity, across which septa of connective tissue passed into the interior of the body, running between the cellular strings.

In this specimen of *M. Eugenii* there was no connexion between median unpaired and lateral paired lobes. In another series of sections I made of a fœtus of *M. Wilcoxii* of about the same length, I found no median lobe existing, but only the lateral lobes, connected by an incomplete bridge of thyroid tissue passing round the trachea from the lower borders of the lateral portions.

There was no trace of a foramen cæcum or a thyroglossal duct.

The Thoracic Thymus. (Pl. 38. fig. 6.)

The thoracic portion of the thymus in *M. Eugenii* consisted of a paired series of parts. It lay almost in the median line of the thorax, in the loose connective tissue in the interspace between sternothyroid muscles (*m.st.*), trachea, and œsophagus (*œ*), and about halfway between the top of the sternum (*st.*) and the anterior limit of the pericardium (*p*), and some little distance above the origin of the sternothyroid and sternohyoid muscles. It was very small, only about 0·5 millim. in its greatest length; the paired parts were not in actual contact, but were separated by an interval of about 0·1 millim. Each half consisted of two lobes, which may be called anterior (*tm.a.*) and posterior (*tm.p.*), since they lay in the longitudinal line of the body. They were approximately equal in size. The two vagi passed along their dorsal surfaces.

These two lobes differed very notably in histological structure. The inferior one (*tm.p.*) presented all the appearance of a thymus; that is, it was composed of small closely compressed cells, which gave a deep coloration with borax-carmine. There was no distinct capsule, and the mass seemed simply to lie embedded in the ordinary connective tissue of the region. A narrow

space surrounded it, due evidently to a contraction of the cell-mass. Capillaries were present in the tissue immediately surrounding the body, but none entered its substance. There was, of course, no distinction as yet into cortical and medullary parts, but septa from the surrounding connective tissue had begun to penetrate into the general cell-mass, whereby incipient lobulation may be said to have commenced.

The superior lobe (*tm.a.*) differed completely in histological structure from that just described. Considering it apart from its relations to surrounding tissues, I should have had no hesitation in describing it as a thyroid, or part of a thyroid mass, judging from its minute structure. It was composed of twisting strings of small cells, with occasional anastomoses. The lumina of these strings were not very evident, but my sections were thick enough to allow of one of them lying uncut, and in optical section the sparseness of the cells in its interior could be easily seen. Where cut in transverse section, they could be seen to be tubes, with contents consisting of scattered cells with indefinite outlines filling up their lumen. The capsule was no more obvious than in the case of the posterior lobe; but the usual annular space surrounded the body, across which sheets of connective tissue could with ease be followed into the interior, ramifying among the cell-strands. There were few blood-capillaries either round or in this body.

I have seen much the same thing in transverse sections of *Macropus Wilcoxii*, and in a series of sections shown me by Mr. M. F. Woodward, which were probably cut from a *Macropus*. In *M. Wilcoxii* there are some differences. The superior lobe of the thymus (Pl. **39**. figs. 11, 13, *tm.a.*, & 12) is by no means so sharply delimited from surrounding parts as in the fœtus described above. For the most part it lies superior to the other lobe of the thoracic thymus, but portions of it are found lateral and even posterior to the latter (Pl. **39**. fig. 11, *tm.a.*). Detached portions of its darkly staining tissue are to be found along the neck for some distance, lying in the tissue surrounding vagi, sympathetics, and internal jugulars. Little nodules lie in the substance of the inferior lobe itself (Pl. **39**. fig. 11, *tm.a.*), round its periphery, and always in little spaces sharply limited by single sheets of connective tissue. Sometimes these are seen in transverse section to be really little follicles enclosing spaces and composed of few cells. Sometimes they are solid cords. The

posterior lobes (Pl. 38. fig. 8, *tm.p.*) are similar in structure to those in *M. Eugenii.*

The Cervical Thymus. (Pl. 38. fig. 7, *tm.c.*)

Symington (1) has described this structure in several forms belonging to the Macropodidæ, and gives a photograph in his paper showing its relationships to the other organs in the neck. As the specimen from which his section was taken was a much older animal than the fœtuses I have examined, I propose to indicate some features of interest exhibited in my sections.

This organ was present in all the specimens I examined. Its structure was that of a thymus. In the more median sections a differentiation into cortical and medullary regions was evident. Secondary lobulation had not progressed to any considerable extent, although septa of connective tissue could easily be traced into the interior of the body. There were indications of the formation of a capsule. Comparatively few blood-vessels were present in the septa. In the portion corresponding to the cortex of a fully-developed thymus the cells were small, closely compressed, and darkly staining; in the central portion they were more sparsely scattered and less darkly staining.

In *M. Eugenii*, from the anterior extremity of the cervical thymus a cord of cells (fig. 7, *c.c.*) could be followed upward towards the head. This cord was surrounded by loose connective tissue continuous with, and in fact expanding over, the connective tissue surrounding the gland. It was not a continuous string of cells, but consisted rather of detached elements; there was, however, a continuous tract of rather dense connective tissue, in which these lay. Occasionally these tracts of cells could be seen to be aggregated together into follicular structures, each consisting of a group of little darkly staining cells surrounding a more or less well-defined space. These cells stained less darkly with carmine than those composing the thymus. Indeed the portions of which this string was composed resembled nothing so much in histological structure as the thyroid itself at this stage, and the whole thing might fitly be compared to a thyroid body of the stage of development represented by the specimen, ravelled out to form an elongated series of imperfect follicular masses more or less connected with each other. At the anterior extremity of the cervical thymus

these cell-strings could be traced into actual contiguity with the substance of that, but there was no confluence of tissue.

At the distal extremity (considered with respect to its origin from the cervical thymus) this cell-tract ran along the inferior and lateral aspect of the submaxillary gland (*s.m.*). Here the sternomastoid muscle (*m.sm.*) passed externally and dorsally to it, and the cord passed between salivary gland and muscle. The omohyoid (*m.oh.*) appeared in the same sections, and the cell-strand passed beneath this muscle and could be traced curving upwards round the dorsal border of the submaxillary gland, running externally at the same time with respect to the median line of the body.

The disposition of this curious structure may be best realized by the aid of the following consecutive series of somewhat diagrammatic sketches of the region in question.

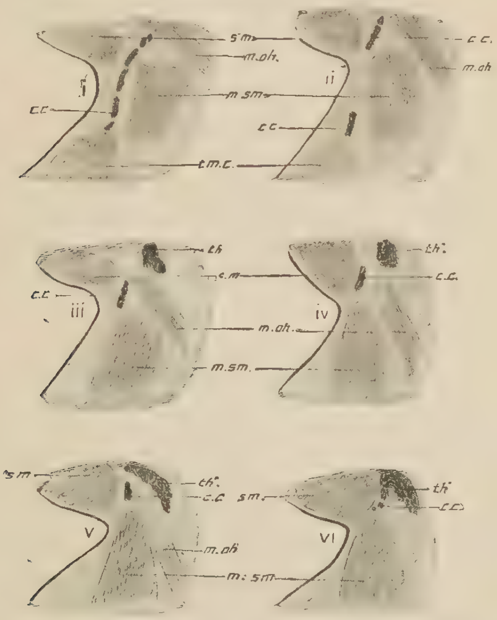

Fig 1.—*Macropus Eugenii*, pouch-specimen. Series of sections representing the passage of the cord of cells extending between the cervical thymus and the lateral lobe of the thyroid. (References, see text.)

The sketches represent a series of longitudinal sections taken

through the neck to the left of the middle line, in order of numbers placed in the angle formed by head and breast. In i. the cord of cells (*c.c.*) can be seen running between the sternomastoid muscle (*m.sm.*) and the submaxillary gland (*sm.*), and proceeding from the cervical lobe of the thymus (*tm.c.*) ; a section is omitted between i. and ii., in which last it can be seen to pass underneath the omohyoid muscle (*m.oh.*). In iii. the lateral lobe of the thyroid (*th.*″) appears, and the posterior part of the cord of cells passes out of the plane of the section. Then omitting another section, in iv. it curves round the dorsal and posterior surface of the submaxillary gland (*sm.*); and in v. (two sections omitted) it can be seen approaching the lateral lobe of the thyroid (*th.*″). Finally in vi., after omitting four sections in which the proximity to the thyroid becomes greater, it joins a little ventral descending process of the latter.

Hence we have the somewhat remarkable arrangement in at least this *Macropus* of a cord of cells connecting the cervical portion of the thymus with the lateral lobe of the thyroid of the corresponding side. I have seen this cervical thymus both in *Macropus Wilcoxii* and in Mr. Woodward's sections, but neither showed the connecting strand of cells. In the former, however, the cervical thymus, which was rather small, lay near to the lateral lobe of the thyroid. But in this case the distinction between paired lateral and median unpaired lobes of the thyroid did not exist, the latter consisting only of two lateral portions joined together by an attenuated bridge of thyroid tissue.

VI. Notoryctes typhlops.

Through the kindness of Prof. Howes I have had the opportunity of examining a specimen of this curious marsupial. At the time when I examined it I was not thinking of a detached superficial cervical thymus, but my notes and drawings give no indication of such an organ being present. The thoracic portion of the organ is of the characteristic type, and presents no special features. It lay below the large first rib, and extended down to nearly the third. To naked-eye examination it gave a perfectly normal appearance, although it was closely adherent to the surface of the pericardium, and very thin and flattened out. On microscopic examination it showed only a few separate

nodules of tissue, presenting all the characters of a thymus. These were embedded in an adipose matrix. Evidently fatty degeneration had gone on to a marked extent.

VII. General Considerations.

With one exception (the Koala) I have found the thymus present in all Marsupials I have examined. It is difficult to say much with regard to variation in size, since the time at which the organ begins to undergo fatty degeneration is probably very different in different forms. Thus in a full-grown *Didelphys pusilla* I found a very large thymus, with few indications of fatty degeneration. In two specimens of *Trichosurus*, both in bad and ill-nourished condition, the thymus, on the other hand, was reduced to a mere vestige, difficult to recognize, and very likely to be passed over in the course of general dissection. It is nearly always that part of the gland lying on the roots of the carotids which persists, although, as various authors have pointed out, the shape of the portion which lies over the base of the heart can usually be recognized in the fat-mass to which it has been reduced. This is not always the case, and some variation in shape, too, exists. As a rule in the Marsupialia the thymus consists of several lobes united in a common connective-tissue investment, not necessarily symmetrical in relation to the median body-line. In the young *Trichosurus* I dissected there were two lobes which were roughly lateral, paired, and anterior, and one lobe which was unpaired, approximately median, and posterior, and this disposition seems to be the usual one. In *Thylacinus* there were two lateral and paired lobes, an anterior fat-body which probably represents a former mass of thymus-tissue anterior to the paired lobes, several approximately median masses, and an asymmetrical and expanded mass lying on the upper half of the heart. On the other hand, in *Cuscus*, a form nearly allied to *Trichosurus*, I found one undivided median mass lying on the base of the heart, and showing short paired and anteriorly pointed prolongations passing upwards some little distance along the course of the carotids. In some cases it would seem as if such cervical prolongations of the thoracic mass of the thymus had existed; but in the retrogressive development of the organ these have been usually the first parts to suffer degeneration.

Generally, as in many other mammals, the thymus extends down-

wards from about the transverse level of the first rib to about the middle of the pericardial sac. Sometimes, however, as in the young *Trichosurus* referred to above, it lies quite above the first rib. On the contrary, in at least the case of a fœtal *Perameles* I have found it to extend down below the apex of the heart, and I suspect, from the appearance of the fat-mass round the heart in *Dasyurus*, that a similar disposition had obtained there. This downward extension of the thymus to the heart apex in some Marsupials is somewhat remarkable. As a rule it lies quite ventral to the pericardial sac, but here too there is an exception in at least *Didelphys pusilla*, where it extends dorsally and laterally until it approaches dorsally the mid body-line. There is thus some considerable variation both in size, shape, and extent of degeneration at corresponding periods in the life-history.

With the exception of some of the fœtal forms I have examined, my material was but ill adapted for close histological examination. I have not observed Hassall's corpuscles to be invariably present, and never in the early stages of development. The best examples of these structures I have seen were in the degenerated thymus of the adult *Trichosurus* referred to above.

The case of *Phascolarctus* is a remarkable one. Alone among the Marsupials I have examined, this form gave no evidence of possessing a thymus. But the specimens were young ones, and since it seems to be the case that in many Marsupials this organ develops comparatively late in life, it would be easy to overlook the very small rudiment of a thymus which might possibly be present. But I am convinced that in the mediastinal cavity there was no such organ, either in rudiment or vestige. From analogy to other Phalangeridæ and the Macropodidæ, it was in such a case that a cervical lobe of the organ might reasonably be looked for. This, however, after diligent scrutiny I failed to find.

It may be worth while to give here a diagrammatic representation of the system of organs in *Macropus Eugenii*. The figure has been reconstructed from a series of sections, but is not accurately drawn to scale.

The thyroid is present in the form of 3 rudiments or lobes, a median unpaired (*th.*) and two lateral and paired lobes (*th.″*). The thymus is represented by four lobes in the thorax, two on either side of the middle line. The anterior pair (*tm.a.*) differ notably, as we have seen, from the posterior pair (*tm.p.*). These

various lobes are unconnected with each other save by loose connective tissue. Lastly, there are the two large, lateral, cervical lobes of the thymus (*tm.c.*) which have been described by Symington, and which in my specimen were connected with the

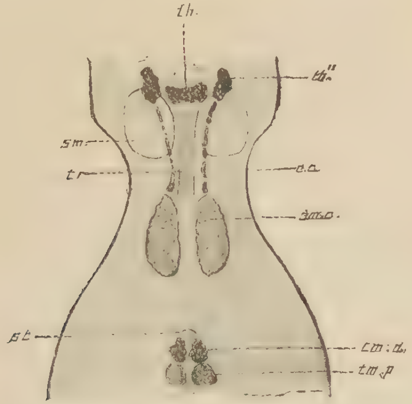

Fig. 2.—*Macropus Eugenii*, pouch specimen. Diagram of the thyroid, thymus, and associated structures.

thyroid by the cord of cells (*c.c.*), which resembled the latter in histological structure.

With the exception of the lateral lobes of the thyroid, all these structures lay ventral to the trachea (*tr.*). Ventral to all are the submaxillary glands (*sm.*), delineated in outline.

I am unable to say whether this peculiar connexion of cervical thymus with lateral thyroid is peculiar to the family or only a specific character. In the two other series of sections referred to above it was absent. Possibly it may occur generally in the development of the Macropodidæ, though at different times, and all my specimens were approximately of the same age. But considered in the light of known facts of the development of the neck-glands in the Mammalia, its presence is suggestive, and points to the association in early development of the cervical thymus and the lateral rudiments of the thyroid.

In late years the development of these glands in various mammals and in other classes of Vertebrata has been very thoroughly worked out. It has been shown by de Meuron

and others that the details of that development vary in many important details in different Vertebrata. In the Selachians the thymus originates as a paired series of outgrowths from the dorsal parts of the walls of the 2nd, 3rd, 4th, and 5th branchial pouches. In the ascending series of vertebrates a considerable reduction in the number of gill-sacs involved in the process takes place. In the Batrachians only the 2nd contribute. In *Lacerta* at least among the reptiles the thymus arises from the 2nd, 3rd, and 4th. In the chick from the 3rd and 4th. But in both lizard and chick it is the part originating from the 3rd pouch which is the more important. The dorsal outgrowth of the 4th contributes only a small portion of the definitive organ. In all these classes the thymus takes its origin exclusively from the dorsal portions of the epithelium of the pouches.

In the Mammalia the reduction goes further. Although the 4th gill-sac does indeed still possibly form a part of the organ, that is only a very small part. de Meuron (**5**) has worked out the genesis of both thyroid and thymus in the sheep, and I follow his account. In the embryo of 15 mm., the 3rd branchial pouches have become quite separate from the pharynx. The median portion of the pouch (which is indeed the only portion remaining) still shows the original lumen which communicated with that of the pharynx. On the dorsal side there is a solid swollen thickening of the wall of the pouch, and opposite this, and directed ventrally, is a long diverticulum into which the lumen is prolonged. This ventral diverticulum descends the neck, dragging with it the solid dorsal thickening, and approaches the base of the heart. Both parts undergo the same histological changes, and take on the characters of thymus-tissue. They lose their epithelial appearance, and trabeculæ of connective tissue invade their substance. The dorsal parts remain for some time attached to the ventral diverticula, which fuse together over the base of the heart by their posterior extremities.

Similarly the thyroid has a multiple origin. There is the unpaired ventral diverticulum in the middle line, and in addition the 4th branchial pouches form paired, ventral, pocket-like prolongations, which also enter into the formation of the definitive thyroid body. Like the 3rd branchial pouches, the 4th give rise not only to the ventral pockets but to dorsally placed thickenings.

Unlike the 3rd, however, these parts differentiate along distinct lines; the ventral pocket loses its lumen and takes on the characters of the median thyroid. The dorsal part comes to resemble the thymus. The portion of the pouch carrying both structures comes to be separated from the pharynx. They part company, and the ventral portion enters into the composition of the definitive thyroid. The dorsal thickening finally becomes lodged within the capsule of the definitive thyroid at the posterior border of the latter. It still retains, however, its thymus-like structure.

It has been shown within comparatively recent times that various structures are constantly met with in association with the thyroid. These were first definitely described by Sandström in 1880, and termed by him "parathyroid glands." Sandström believed these bodies to consist of portions of thyroid tissue retaining more or less their embryonic structure. It was pointed out in 1894 by Prenant (6), and in 1895 by Kohn (7), that these bodies were distinct in structure from the thyroid, and had in fact a morphological individuality of their own. Kohn further proposed the terms "internal and external epithelial bodies" as substitutes for Sandström's original names, preferring these since they presupposed no morphological relationship to the thyroid. Kohn showed that these bodies vary somewhat in minute structure and in position with respect to the lateral lobes of the thyroid, and that the external body is always either free from the latter organ or incompletely buried in its substance, while, on the other hand, the internal capsule is always completely included in the tissue of the thyroid. In 1896 the important memoir of Simon appeared, and within the last few months the papers of Welsh (4).

Simon (8) took exception to some of de Meuron's conclusions as to the development of the derivatives of the 4th branchial pouch. He contended that the account of the latter author of the origin of the "glandule thyroïdienne" was probably erroneous. Instead of this body originating in a dorsal thickening of the wall of the 4th pouch as de Meuron supposed, it according to Simon develops as a differentiation of the diverticulum of that which forms the lateral anlage of the thyroid. Further, Simon emphasizes the fact, already insisted on by de Meuron and others, that the greater part of the definitive thyroid is formed

from the median anlage, and that the lateral anlagen always remain very unimportant organs in respect of size, and never intimately fuse with the main body of the gland. Nevertheless these lateral thyroids are in a way comparable to the median thyroid, as is indicated by the persistence for a certain period of the hollow peduncle uniting them with the original branchial clefts —the "canal thyreo-pharyngien."

The developmental history of the internal and external epithelial bodies of Kohn was worked out by Simon, and the insufficiency of these terms pointed out. The internal epithelial body he showed to be identical with the "glandule thyroïdienne" and a derivative of the 4th pouch. The external epithelial body, on the other hand, is identical with the "glandule thymique" and takes its origin from the 3rd—that which gives rise to the thymus. In addition to these epithelial bodies, the lateral lobes of the thyroid enclose nodules of tissue of lymphoid or thymic nature. The genesis of these bodies has been treated in a somewhat unsatisfactory manner by Simon, who considered them to be appendages of the thymus, but it is evident that their development requires further investigation.

Neither the embryology of the thyroid and thymus, nor the question of the presence or absence of epithelial bodies in the former, has been worked out in the Marsupials. Judging from the disposition of the organs in the young animal, it would seem that the development of those structures might differ in many details, both from that in the other Mammalia outlined above and indeed in the various families of Marsupials themselves. Thus the presence of a cervical thymus and the association of this body with the lateral lobe of the thyroid are points of difference. For it is not probable, as Symington has indicated, that the cervical thymus is developmentally the same structure as the cervical prolongations of that organ found in some other mammals. And the absence in the young marsupial of any structures exactly resembling "epithelial corpuscles" offers another point of dissimilarity.

The cervical thymus may probably arise from the 4th branchial pouch. This is suggested by its association with the lateral lobe of the thyroid, assuming that the latter represents a part of the thyroid developed from the 4th pouch as in the other mammalia. This, however, is by no means certain. Then the cell-

tract uniting these two bodies may be compared with one of the epithelial corpuscles, probably the internal one, and the cervical thymus itself with the internal thymic lobule which is usually found in the thyroid of the mammalia. The other (external) corpuscle would thus be absent. I have not cut serial sections of the thyroid of any marsupial possessing a cervical thymus, but in such the internal thymic lobule of the thyroid may not unreasonably be expected to be absent; and it is suggestive in this connexion that in the young *Perameles*, where a cervical thymus is absent, indications of such an intra-thyroid thymic nodule are present.

But in the lack of any exact knowledge of the development of these organs, such explanations can only be tentative.

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EXPLANATION OF THE PLATES.

PLATE 37.

Fig. 1. Thoracic organs of *Dasyurus viverrinus*. $\frac{2}{3}$ nat. size.

2. Dissection of thorax and lower neck of a young *Trichosurus vulpecula*. $1\frac{1}{3}$ nat. size.
3. Dissection of the neck of *Perameles Gunni*. $\frac{2}{3}$ nat. size.
4. Dissection from the ventral side of the thorax and lower part of the neck of *Thylacinus*. About $\frac{1}{2}$ nat. size.
5. Dissection of thorax of *Cuscus orientalis*. Nat. size.

PLATE 38.

Fig. 6. Longitudinal section of part of the thorax of *Macropus Eugenii* a little to the left of the middle line of the body. Mag. about 30 diameters.

7. Longitudinal section through the neck of *Macropus Eugenii*, to the left of the middle line. Mag. about 30 diameters.
8. *Macropus Wilcoxii*. Transverse section of thorax. Mag. about 40 diameters.
9. *Perameles Gunni*. Transverse section of thorax a little below the 1st rib. Mag. about 13 diameters.

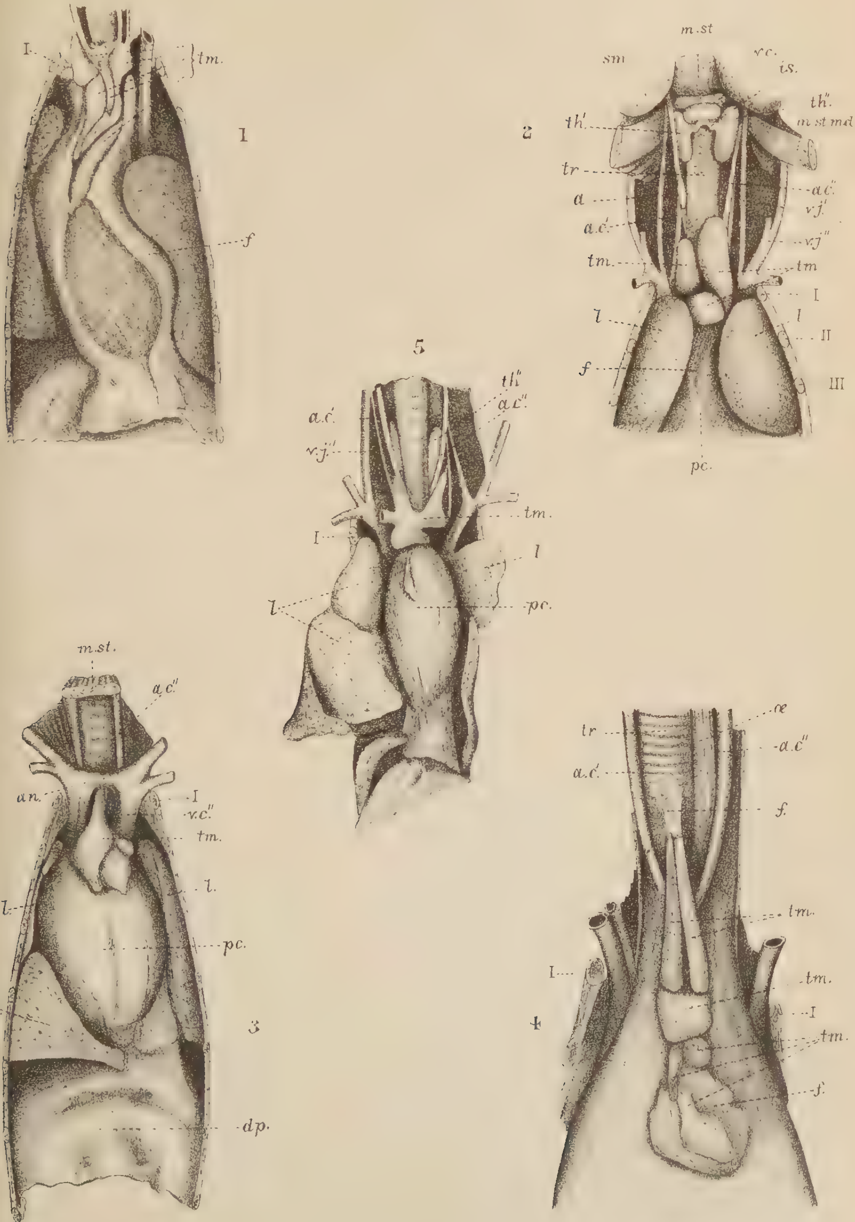
PLATE 39.

Fig. 10. Transverse section of the thoracic organs of *Didelphys pusilla*. Mag. 10 diameters.

11. *Macropus Wilcoxii*. Transverse section of part of the posterior lobe of the thoracic thymus. Mag. about 200 diameters.
12. *Macropus Wilcoxii*. Transverse section of the anterior lobe of the thoracic thymus. Mag. about 200 diameters.
13. *Macropus Wilcoxii*. Transverse section of part of the thorax, passing through the anterior lobes of the thoracic thymus. Mag. about 30 diameters.

Reference Letters.

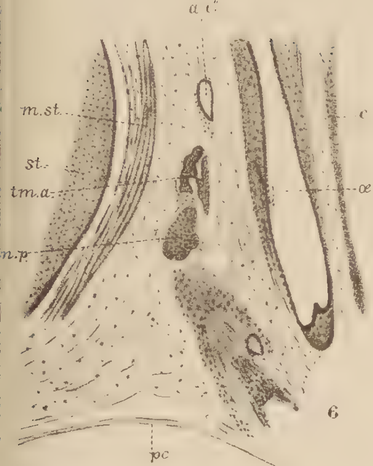
a.c'. Right common carotid artery.
a.c''. Left common carotid artery.
a.sc'. Right subclavian artery.
a.sc''. Left subclavian artery.
a.i. Innominate artery.
an. Solid anastomosis between the superior venæ cavæ.
b. Placed in the bay formed by the flexure of the head.
c. Centrum of vertebra.
c.c. Cellular tract uniting cervical thymus and lateral lobe of thyroid.
cr. Cricoid cartilage of the larynx.
cl. Clavicle.
dp. Diaphragm.
f. Fat.



J. Johnstone del.
Parker & Percy lith.

Geo West & Sons imp.

NECK GLANDS OF MARSUPIALIA



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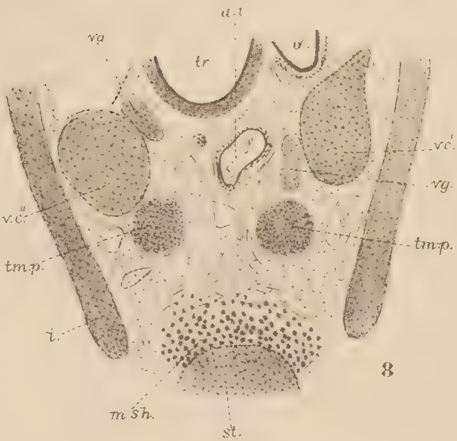

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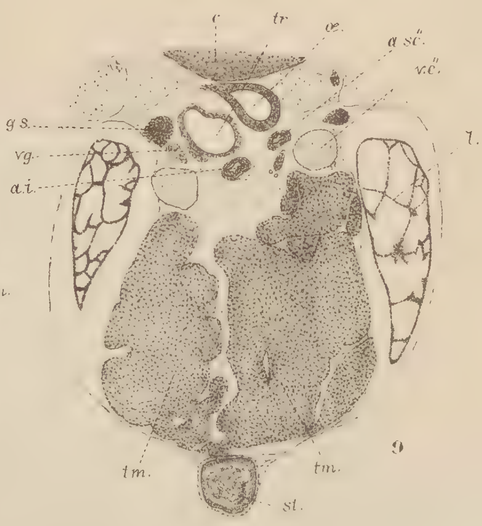

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J. Johnstone del.
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NECK GLANDS OF MARSUPIALIA.

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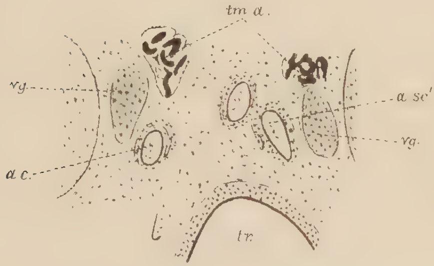

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J. Johnstone del.
Parker & Percy lith.

Geo. West & Sons imp.

NECK GLANDS OF MARSUPIALIA.

g.s. Sympathetic ganglion.
is. Isthmus of thyroid.
l. Lung.
m.sh. Sternohyoid muscle.
m.oh. Omohyoid muscle.
m.sm. Sternomastoid muscle.
m.p. Pectoralis muscle.
m.st. Sternothyroid muscle.
œ. Œsophagus.
pc. Pericardium.
st. Sternum.
sm. Submaxillary gland.
tm. Thymus.
tm.a. Anterior lobe of thoracic thymus.
tm.c. Cervical lobe of thymus.
tm.p. Posterior lobe of thoracic thymus.
th. Median lobe of thyroid.
th'. Right lobe of thyroid.
th''. Left lobe of thyroid
tr. Trachea.
v.c'. Right superior cava.
v.c''. Left superior cava.
vg. Vagus nerve.
v.j'. Internal jugular vein.
v.j''. External jugular vein.
I., II., III. Ribs 1 to 3.

Natural Selection the Cause of Mimetic Resemblance and Common Warning Colours. By Edward B. Poulton, M.A., F.R.S., Hope Professor of Zoology in the University of Oxford.

[Read 17th March, 1898.]

(Plates **40–44**.)

Contents.

(1) *Historical Introduction.*

Superficial resemblances between animals, especially numerous in Insecta, were known long before H. W. Bates's paper "Contributions to an Insect Fauna of the Amazon Valley" was read before the Linnean Society on November 21st, 1861, and published in the 'Transactions' the following year (vol. xxiii. p. 495). Some

of the principal records of such observations are to be found in the 'Transactions' of this Society.

W. S. MacLeay, in his 'Horæ Entomologicæ' (London, 1819 and 1821), alluded to certain cases which are now included under Mimicry, viz. the likeness of some Diptera to Hymenoptera (Pt. II. p. 365), and interpreted them, together with many other resemblances of structure and life-history, by the principle of Analogy as distinct from Affinity in Nature. These views were adopted by MacLeay's immediate successors.

The Rev. William Kirby read "A Description of some Insects which appear to exemplify Mr. William S. MacLeay's Doctrine of Affinity and Analogy," before this Society on Dec. 17th, 1822, and the paper was published in the 'Transactions' (vol. xiv. p. 93).

Boisduval, in the 'Spécies Général des Lépidoptères,' published in 1836, remarked (pp. 372, 373) on the resemblance between certain West African butterflies belonging to very different groups.

Prof. Westwood read "Illustrations of the Relationships existing among Natural Objects, usually termed Affinity and Analogy, selected from the Class of Insects," before this Society, on Jan. 17th and May 2nd, 1837, the paper appearing in the 'Transactions' (vol. xviii. p. 409). In the paper many new examples were published and figured, while MacLeay's views were criticised and expanded in an interesting manner.

The same recognition of Mimicry is equally well seen in the names with the termination *-formis* given to so many of our moths, indicating their resemblance to wasps, bees, and other insects. In spite, however, of the knowledge of a large number of instances, the subject made no real progress until the appearance of H. W. Bates's paper. The view then set forth that the resemblances are in themselves beneficial to the possessor was, as far as I am aware, only once suggested before,—in the well-known 'Introduction' by Kirby and Spence. In Vol. II. p. 223 of the second edition (1817) the authors write as follows:—"Some singular larvæ with a radiated anus live in the nests of humble-bees, and are the offspring of a particular genus of flies (*Volucella*, Geoffr., *Pterocera*, Meigen), many of the species of which strikingly resemble those bees in shape, clothing, and colour. Thus has the Author of nature provided that they may enter those nests and deposit their eggs undiscovered. Did these

intruders venture themselves amongst the humble-bees in a less kindred form, their lives would probably pay the forfeit of their presumption." This interesting paragraph, although fully recognizing the utility of mimetic resemblance in species which were then believed to have been separately created and to have come into existence fully formed and complete, sustains a position which is the very antithesis of that taken up by Bates. The contention that the utility of the resemblance has been the cause of its persistence, and, by the selection of variations going further in the same direction, of its improvement, would have been rejected, probably with indignation, by the distinguished authors of the 'Introduction.'

Bates's great paper dealt with the fauna of tropical America, and the generalization was manifestly incomplete until it had been extended to other parts of the world. This confirmation was not long in coming, being supplied for the tropical East by A. R. Wallace's paper published in the 'Transactions' of this Society (1866, vol. xxv.), and for Africa by Roland Trimen's paper, also to be found in our 'Transactions' (1870, vol. xxxi.).

It is remarkable how completely the Linnean Society has been the medium for the publication of classical memoirs upon Mimicry. Up to the year 1870 it contained them all: while in 1858 it served as the channel through which the parent theory of Natural Selection was first given to the scientific world. The next great advance did not take place until 1879, and was published elsewhere

Bates had called attention to certain resemblances which could not be interpreted under his theory of mimicry, viz. the frequent similarity between the specially defended forms themselves. Forms which are themselves the models for mimicry nevertheless mimic or at least resemble other models. For such cases Bates could only suggest the direct action of some unknown local force or forces, and Wallace followed him in this.

In May 1879 Fritz Müller published a paper in 'Kosmos'* which for the first time offered an explanation, based on the theory of natural selection, of these mysterious resemblances. He suggested that such likeness between dominant forms was advantageous to them, inasmuch as it facilitated the education of their enemies, reducing the amount of destruction which must be wrought during the time in which young birds and other

* "*Ituna* and *Thyridia*: a remarkable case of Mimicry in Butterflies."

animals are learning what to eat with impunity and what to reject. The paper was translated by Prof. R. Meldola and published in this country almost immediately after its appearance (Proc. Ent. Soc. Lond. 1879, p. xx).

The facts which the Müllerian theory sought to explain concerned the fauna of tropical America; the naturalist who explained them was a resident in the same part of the world. A few years later, however, F. Moore (Proc. Zool. Soc. 1883, p. 201) showed that there is the same resemblance between the dominant butterflies of the tropical East; and last year I pointed out that the same facts hold in Africa (Report of the British Association at Toronto, 1897, pp. 688–691). See also Roland Trimen's Presidential Address to the Entomological Society, Jan. 19th, 1898 (Proceedings, 1897, p. lxvi). In the 'Proceedings' of the Entomological Society (1897, p. xxix), as well as in the former paper (p. 691), I argued that such resemblance is not true Mimicry at all, but rather an example of Common Warning Colour, and with the assistance of Mr. Arthur Sidgwick I suggested the term *Synaposematic* as descriptive of it; the term Aposematic having been previously suggested for ordinary Warning Colours (Poulton, Colours of Animals, Internat. Sci. Ser., London, 1890, p. 337).

I have now given a brief account of the leading phases in the history of Mimicry. Even before the appearance of Fritz Müller's paper a great effect had been produced. This immediate stimulus to the investigation of new examples and fresh aspects of Mimicry which followed Bates's memoir, must be ascribed to the fact that then for the first time was offered a good working hypothesis—a hypothesis which seemed to afford an adequate explanation of one class of known facts, which challenged its critics to find insuperable difficulties among facts as yet unknown. In the thirty-six years which have elapsed since the appearance of this great memoir an immense number of facts bearing upon the subject have been discovered, and many naturalists consider that Bates's theory of Mimicry as due to natural selection (supplemented and completed by the kindred theory which we owe to Fritz Müller) has stood the test with complete success and is in a far stronger position than in 1862. This opinion is more generally held among the students of other groups of the animal kingdom than among those who are specially devoted to entomology, but a considerable proportion of the latter also hold it firmly.

In the summer of last year (1897) an excellent opportunity of gauging the opinion of entomologists upon this question was presented by a discussion carried on at two successive meetings of the Entomological Society of London. From the printed report in the 'Proceedings' of the Society, I select the following adverse expressions of opinion as regards the adequacy of natural selection to produce mimetic resemblance, and the statements of any alternative theories or suggestions to account for the facts. The quotations are given in the order in which they are printed.

Mr. W. F. H. Blandford said "it was conceivable that the causes, in most cases unknown, which brought about modifications in the colour and markings of a species in association with its geographical range, might have produced identical results in two species of the same genus, with a common facies, under common conditions." This sentence seems to suggest cautiously the direct influence of climate or some other cause connected with locality. Mr. Blandford, although not disputing the theories of Bates and Fritz Müller, considered that "they rested very largely on hypothesis and were in want of further support from observation and experiment," and that they failed to account for the perfection of the resemblance.

Mr. H. J. Elwes thought "there was too much assumption about either the Batesian or Müllerian theories of mimicry," and he doubted the inedibility of the so-called models, and of the members of the Müllerian groups. Some examples were quoted by him as suggestive of similar effects wrought by similar conditions of environment.

Mr. Jacoby considered that the evidence of special protection was insufficient.

Sir George Hampson "thought the cause demanded by these theories was inadequate to produce the results assigned to it." In S. India he had found it "quite an exceptional thing to see birds catch, or even attempt to catch, butterflies."

The Hon. Walter Rothschild considered "it was much more conceivable that certain climatic influences, &c., had played a part in bringing about these resemblances, and he thought that these groups assumed the same appearance because one given influence was at work on them."

Canon W. W. Fowler thought "there was too much assumption about the current theories."

Mr. McLachlan suggested "the possibility that two species might go on independently and yet apparently mimic each other by arriving at the same results in their modifications."

Mr. J. J. Walker and Col. Yerbury argued that birds are not "effective agents in causing mimetic resemblances."

Mr. Blandford, replying at the close of the debate, maintained that extremely close and exact resemblances are "hypertelic,"—going beyond the limits of the useful, and therefore inexplicable by natural selection. He restated and brought further support in favour of the opinion that birds rarely attack butterflies. He made the final suggestion that possibly "sexual selection, or the segregation of forms might take place as a direct act of perception on the part of the insects themselves"; and quoted the observation of H. W. Bates that the *Ithomiæ* when pairing tend to select none but their exact counterparts (Trans. Linn. Soc. vol. xxxiii. 1862, p. 501).

Only four speakers gave full support to the theories of Bates and Fritz Müller, as explaining the facts more satisfactorily than any other theory hitherto proposed and as likely to receive further confirmation in the future. These four were the President Mr. Roland Trimen, Dr. Dixey, Colonel Swinhoe, and the present writer.

(2) *The various Hypotheses which have been proposed as Substitutes for Natural Selection as the Explanation of Mimicry and Common Warning Colours.*

In the course of the discussion thus briefly epitomized, almost every alternative theory which has been proposed to account for the facts was brought forward.

These theories are as follows:—

(1) The direct effect of some physical or chemical cause or causes connected with locality, such as climate, food, &c. This hypothesis received much support. It may be called the Theory of External Causes.

(2) The independent evolution of a similar appearance in distinct species. This hypothesis was suggested by Mr. McLachlan, and I have heard a similar opinion expressed by Prof. Patrick Geddes. This appears to be the view sustained in G. H. Eimer's just published work 'Orthogenesis der Schmetterlinge' (Leipzig, 1898). I have not yet had the opportunity of studying the essay, but my friend Prof. Weldon has done so

and tells me that it supports a theory of mimicry as due to internal developmental causes, compelling different species to pass through similar phases. The hypothesis that "laws of growth" may cause these resemblances also falls into this category. The suggestion that such laws may account for certain phenomena which are usually explained by the theories of natural and sexual selection was made by Prof. D'Arcy Thompson at the Oxford meeting of the British Association in 1894. This may be called the Theory of Internal Causes.

(3) The operation of Sexual Selection, cautiously suggested as a possibility by Mr. Blandford, who did not, on this occasion, develop the details of the manner in which the principle may be supposed to act. Fritz Müller had suggested this idea in a letter to Darwin, who wrote not unfavourably of it to Prof. Meldola, on Jan. 23rd, 1872. "You will also see in this letter a strange speculation, which I should not dare to publish, about the appreciation of certain colours being developed in those species which frequently behold other forms similarly ornamented. I do not feel at all sure that this view is as incredible as it may at first appear. Similar ideas have passed through my mind when considering the dull colours of all the organisms which inhabit dull-coloured regions, such as Patagonia and the Galapagos Islands" ('Charles Darwin and the Theory of Natural Selection,' Poulton (London, 1896), p. 202.)

In the present paper the attempt will be made to show that many of the known facts of mimetic resemblance do not admit of interpretation by any of the three theories mentioned above, while they do receive a ready explanation on the supposition that the resemblances are useful and have been produced by natural selection. Certain new observations upon the details of the resemblances in a large group of insects, undertaken specially to test these rival theories, will be found to point strongly in the same direction (see Section 12).

In order to render the argument as complete as possible, various considerations which have been urged before will be included as well as those which now appear for the first time.

The objection may be raised that such detailed treatment is unnecessary, and that biologists generally agree in attributing these resemblances to natural selection. To this contention the discussion at the Entomological Society is sufficient answer.

(3) *The Relation of the Resemblances under Discussion to other Resemblances in Organic Nature.*

To those who accept natural selection as the explanation of mimicry, the facts under discussion fall into their place as part of the much wider group of Protective Resemblances in general. Mimicry becomes merely "an exceptional form of protective resemblance" (Wallace, 'Darwinism,' London, 1889, p. 265). The following classification was suggested by the present writer, with the assistance of Mr. Arthur Sidgwick, in 1890 ('The Colours of Animals,' Internat. Sci. Ser., London, 1890, p. 338):—

<table>
<tr><td colspan="2">I. Apatetic colours.—Colours resembling some part of the environment or the appearance of another species.</td><td rowspan="2">II. Sematic colours.—Warning and signalling colours.</td><td rowspan="4">III. Epigamic colours. — Colours displayed in courtship.</td></tr>
<tr><td>A. Cryptic colours. Protective and Aggressive Resemblances.</td><td>B. Pseudosematic colours. — False warning and signalling colours.</td></tr>
<tr><td>1. Procryptic colours. — Protective Resemblances.</td><td>1. Pseudaposematic colours.— Protective Mimicry.</td><td>1. Aposematic colours. — Warning colours.</td></tr>
<tr><td>2. Anticryptic colours. — Aggressive Resemblances.</td><td>2. Pseudepisematic colours. — Aggressive Mimicry and Alluring Coloration.</td><td>2. Episematic colours. — Recognition markings.</td></tr>
</table>

Thus the facts of mimicry fit into a broad system which includes the other resemblances in organic nature. The relation between protective resemblance (I. A. 1) and protective mimicry (I. B. 1) is as follows:—In the former an animal resembles some object which is of no interest to its enemy, and in doing so is concealed; in the latter an animal resembles an object which is well known and avoided by its enemy, and in doing so becomes conspicuous. Thus mimicry as interpreted by H. W. Bates finds its place in I. B. 1, while the resemblance between protected conspicuous forms (sometimes, but, as I think, erroneously, called mimicry), as interpreted by Fritz Müller ('Kosmos,' May 1879, p. 100, translated by Meldola in Proc. Ent. Soc. Lond. 1879, p. xx), falls into II. 1. Such cases only differ from ordinary warning colours in that they are common to two or more species: hence,

as has been already pointed out, the term *synaposematic* colours, or common warning colours, may be conveniently applied to them.

The arguments in favour of natural selection as the explanation of protective resemblance run entirely parallel with those which favour it as the interpretation of mimetic resemblance and common warning colours. By modifying the examples and, in some cases, the form of the argument, nearly every section of this paper might be converted into a defence of the former, and the arguments which are strongest in support of the one are the strongest in support of the other, viz. those contained in Sections 4, 5, 6, 7, 11, and 12.

Under the theory of natural selection all the resemblances among animals, mimetic and other, show the clearest relationship, and (with the exception of the debated Epigamic colours) are to be explained by the working of a common principle, viz., the selection of variations which are useful in the struggle for existence. Under the other theories mentioned above no such grouping can be readily brought about, and mimetic resemblance becomes due to one set of principles and the other resemblances to another set. The majority of those who look on mimicry as due to external or to internal causes, or to sexual selection, would probably agree in explaining protective resemblance by natural selection. And yet these latter cases, while far more common, are often as detailed and as remarkable as those of mimicry. Those who adopt the most extreme form of the theory of external causes might perhaps maintain that the resemblance to twigs, leaves, and bark is to be explained in the same manner, and would thus bring protective and mimetic resemblance under the operation of the same set of forces; but few will be prepared to carry the theory so far. Under the theory of internal causes it is impossible to bring the two kinds of resemblance together; for while it is held by some that two or more animals may independently and without selection arrive at corresponding points in their evolutionary history, which are such as to involve mimetic resemblance, no one could believe that the similarity to bark or earth has been produced in the same manner. Those who are inclined to accept sexual selection as the explanation can only bring the two classes of facts together by supposing that the appearance of some minute portion of the total vegetable or mineral environment has acted as a stimulus and has led one sex to select the other

according as it resembled the object in question; just as a similar selection has been supposed to take place from the stimulus supplied by the appearance of another species. Probably no one is prepared to adopt this view as regards the former class of facts, although Darwin had, as the above-quoted letter shows, considered the possibility of the general tints of the environment influencing the trend of sexual selection in this way.

A fatal objection to any explanation based on the theory of sexual selection is the fact that protective resemblances are so extremely common and perfect in the immature stages of insects. The same objection holds, although with less force, against its use as an explanation of mimetic resemblance.

The conclusion appears inevitable that under no theory except natural selection do the various resemblances of animals for their organic and inorganic environments fall together into a natural arrangement and receive a common explanation. On any theory except natural selection this can only be brought about by the adoption of extreme views as to the area over which the alternative theory is to be applied,—views which, at any rate, the great majority of those who are disposed thus to explain mimetic resemblance are not prepared to adopt.

(4) *Mimetic Resemblance and Common Warning Colours between different Arthropod Classes and between various Insect Orders, and their Relation to Similar Resemblances within the Limits of a Single Order.*

The discussion at the Entomological Society was based almost exclusively upon the phenomena presented by mimetic resemblance and common warning colours affecting the species of a single Order of insects (Lepidoptera), and generally the species of a single Family (*Nymphalidæ*). I cannot but think that this limitation of the survey to one small part of the field over which the resemblances commonly occur is, in large part, the cause of the rejection of natural selection and the substitution of alternative suggestions. There is something attractive and plausible in the suggestion that the strong mutual resemblances within a group of butterflies of different genera and subfamilies, inhabiting a single locality, are due to the direct action of peculiar local physical or chemical influences; but the suggestion loses all its attractiveness when it is applied to the resemblance between a

spider and an ant, or a moth and a wasp. And yet few could bring themselves to believe that the resemblances which are here contrasted have been built up by two entirely different sets of forces. Mr. Blandford alluded to this relationship and gave it as his main reason for accepting Bates's theory, although he rejected the Müllerian theory of Common Warning Colours. This discrimination in favour of the former theory is not justified by the facts. The resemblance between different insect orders has not been as yet sufficiently regarded from the Müllerian standpoint; but there are, and have been for many years, the strongest indications that here also much of the ground formerly believed to be covered by the older theory will be found to be occupied by the newer.

The Müllerian theory by no means demands that the methods of defence in the members of a convergent group should be uniform.

So long ago as 1887 ("The Experimental Proof of the Protective Value of Colour and Markings in Insects in reference to their Vertebrate Enemies," Proc. Zool. Soc. 1887, pp. 191–274) I tabulated the colours and markings of all insects which up to that time had been experimentally proved to be specially defended, and was enabled to apply to the whole group of conspicuous insects the explanation offered by Fritz Müller (*l. c.* p. 227). This general conclusion will be found to be supported by many facts and considerations in the paper referred to.

In alluding to the resemblance which the black-and-yellow-ringed unpalatable larva of *Euchelia jacobææ* bears to a wasp, I wrote (*l. c.* pp. 235, 238):—"Thus it is more than probable (as has been previously suggested by other observers) that the species rendered conspicuous by alternate rings of black and yellow gain great advantages from the justly respected appearance of Hornets and Wasps. It must not be forgotten, however, that the latter forms also probably gain to some extent by the greater publicity which follows from the resemblance."

I may here digress for a moment and invite the attention of those who dwell on the excessive amount of assumption in the theories of mimicry, to the numerous tables in the paper mentioned above. In these will be found recorded the whole of the results of actual experiments made, up to 1887, upon the palatability and unpalatability of conspicuous and inconspicuous insects. It may be safely asserted that the theories in question are not nearly

so devoid of support from the results of experiment and observation as has been represented.

Since 1887 further evidence has been forthcoming in support of the Müllerian explanation; for it has been shown in many cases that insects which resemble specially defended members of another order, themselves belong to a specially defended group within their own order. Thus Haase ('Researches on Mimicry,' part ii. London, 1896, English translation by C. M. Child, p. 70) points out that the South-American moths which resemble "immune" Coleoptera—the *Lycinæ*, "belong to the immune families of the *Glaucopidæ* (*Mimica*, *Lycomorpha*) and *Arctiidæ* (*Pionia*)," and also that (*l. c.* p. 73) the South-American *Glaucopidæ* furnish numerous cases of resemblance to Aculeate Hymenoptera. In a note to the same page Haase adduces some little direct evidence for the inedibility of a Glaucopid.

During the past year Dr. L. O. Howard, of Washington, has kindly presented to the Hope Department, Oxford University Museum, a pair of specimens which prove that the protected moth *Lycomorpha latercula* (Edw.) occurs in the same locality and at the same time of the year as the beetle *Lygistopterus rubripennis* (Lec.), which it closely resembles, the former having been captured on June 18, the latter on June 5, 1897, in the Chiricahua Mountains, Arizona, by Mr. H. G. Hubbard.

Furthermore, the resemblance between the species of the two great sections of the order Lepidoptera—the Rhopalocera and Heterocera—is frequently of the Müllerian rather than the Batesian kind. Thus Sir George Hampson has pointed out that the moth *Abraxas etridoides*, resembling the butterfly *Teracolus etrida*, belongs to a specially protected genus, and that similarly three genera of the *Chalcosia* group of *Zygænidæ*, which are said to resemble Danaine and Papilionine butterflies, are also extremely distasteful to insect-eating animals ('Nature,' 1898, Feb. 7, p. 364). Similarly, Mr. Roland Trimen, in his Presidential Address to the Entomological Society (Jan. 19, 1898), points out that the "abundant and extremely conspicuous, slow-flying, diurnal Lithosiid moth *Alctis helcita*," together with its "apparently protected analogues .... the closely similar Lithosiid *Phæagarista helcitoides*, and Agaristid *Eusemia falkensteinii*," show great similarity to the group which is headed by *Danais chrysippus*,—"so that from the aspect of warning of distastefulness to enemies the two sets may be regarded as practically but

one." Similar facts will probably be found in numerous other examples of moths which resemble the butterflies.

It may be safely asserted that, even with our present limited knowledge, Müllerian resemblance, no less than Batesian mimicry, can be found in the species of groups with all degrees of affinity, and that there is no ground for Mr. Blandford's contention that the latter alone derives support from the facts presented by the groups which include species from different orders.

Under natural selection the interpretation of the whole series of facts is perfectly valid. The dominant forms which in each locality move towards each other and towards which less dominant forms also move, are in some way specially defended. The principles are the same when the approximation is between the species of different orders or suborders, or between those which are much more closely related. The Müllerian theory explains the resemblance of such large numbers of stinging insects to each other and of other specially defended forms to them, whether they be closely or distantly related: it also explains the resemblance of the dominant *Heliconinæ* and *Ithomiinæ* in each locality in South and Central America and of other forms to them. Batesian mimicry explains the cases in which the attracted forms are not specially defended.

The conclusion which emerges most clearly is the entire independence of zoological affinity exhibited by these resemblances; and one of the rare cases in which Darwin's insight into a biological problem did not lead him right was when he suggested that a former closer relationship may help us to understand the origin of mimicry. Further confirmation of this conclusion will be found in the additional details supplied in the succeeding section.

When we look at the phenomena of mimicry and common warning colours as a whole, it is found that the theory of natural selection is equally applicable throughout; while the theories of external causes and internal causes cannot be applied to some of the most striking resemblances, those of moths, beetles, and Diptera to stinging Hymenoptera. The theory of sexual selection is less logically assailable on these grounds; but with the other two suggested substitutes for natural selection, it entirely fails to account for the attractive force exercised by specially protected forms. Under any of these three theories it is a mere coincidence that the insects which are resembled by species of all

kinds happen to possess stings—that the central types in the groups of butterflies belong to subfamilies which are more abundant and even more unpalatable than the generality of their order. It is, furthermore, a mere coincidence that such groups are formed round the *Danainæ* and *Acræinæ*, *wherever they occur in all the warmer regions of the world*, and in tropical America also round the *Ithomiinæ* (*Neotropinæ*), which are closely related to the former, and the *Heliconinæ*, which are closely related to the latter.

No theory except natural selection explains why the number of colours and patterns in the dominant groups of butterflies mentioned above are so few in relation to the number of species, as was pointed out by Prof. Meldola (Ann. & Mag. Nat. Hist., Dec. 1882). These colours and patterns have been recently studied very carefully, especially in the *Ithomiinæ*, by A. G. Mayer (Bulletin of the Mus. of Comp. Zool. at Harvard Coll., Feb. 1897, p. 169). Mayer shows that "the 200 species of *Papilio* in South America display 36 distinct colors, while the 450 species of *Danaoid Heliconidæ* [*Ithomiinæ*] exhibit only 15. Hence the numbers of the *species* and of the *colors* are almost in inverse ratio in the two groups. This may be explained by the fact, that the *Danaoid Heliconidæ* mimic one another, while the *Papilios* do not...... There is no lack of individual variability among the species of the *Danaoid Heliconidæ*; yet the species as a whole vary but little from the two great types of color-pattern represented by *Melinæa* and *Ithomia*. In order to account for this remarkable fact, I am forced to resort to Fritz Müller's theory of mimicry" (*l. c.* p. 229). Again on page 225 Mayer remarks: "It is difficult to account for the remarkable conservatism in respect to color-variations among the *Heliconidæ* [here used, as in Bates's original paper, to include *Danainæ*, *Ithomiinæ*, and *Heliconinæ*], unless we resort to the explanation afforded by the theory of mimicry; for, while there is such remarkable simplicity and uniformity of color-pattern throughout the whole group of the *Heliconidæ*, *individual variations* are very common."

It is not from any predisposition or bias in favour of natural selection that these conclusions are reached, but simply because natural selection offers an explanation of so many remarkable facts which are utterly meaningless under any other theory yet brought forward.

(5) *Resemblances even within the Limits of an Order are entirely independent of Affinity.*

The entire independence of affinity is specially well seen in the groups of convergent moths and butterflies which are found in different localities in South America. Although the resemblance is clear enough in all the members of a large group, it is far closer in certain species than in others. When these are examined they are found not to be more nearly related than other members of the group, but frequently the reverse. Thus it is very common for a species of *Heliconius* to resemble with the most remarkable precision a species of *Melinæa* or some other Ithomiine genus in its locality. Such resemblance is in these cases far closer than that of the former to the species of the other genus (*Eueides*) in its subfamily, and than that of the latter to any species in the numerous related Ithomiine genera. Thus, to illustrate this conclusion from some examples in the Hope Collection, in Honduras by far the strongest resemblance is to be found between a *Heliconius* and a *Melinæa*; and this is also the case (both species being different) in Surinam. In Trinidad the resemblance is closest between a *Heliconius* and a *Tithorea.*

Under the theory of natural selection this association is readily explicable. The pairs which thus form the centres of local groups are probably the dominant forms, relying more completely than the other members upon the defence afforded by their warning colours and the associated unpalatability. As a matter of fact there is some evidence for their exceptional abundance as compared with the other members of their groups. Again, they are usually more nearly of the same size than the other members, so that the perfection of the resemblance in colour and pattern is aided by resemblance in another quality.

The theory of external causes entirely fails to account for these facts. Uniform local conditions, if they can produce any effect at all, must be expected to produce the closest likeness where there is the closest constitutional similarity—in other words, in the more nearly related forms, in preference to the less nearly related, in each locality. With the theory of internal causes we should also expect the facts to be the reverse of those which exist. At the best it is unable to account for the observed phenomena.

Any theory of selection (natural, artificial, or sexual) affords a

logical explanation of the facts, in the sense that it is quite conceivable that the observed results might be thus obtained. Hence the objection to sexual selection as a suggested cause is not as strong as the objection to the other causes which have been brought forward. Nevertheless, I believe that very few will be found to support the former suggestion.

The conclusions here arrived at by a consideration of the facts presented by the Lepidoptera are entirely confirmed by those already known in the Coleoptera; although as yet but little attention has been paid to the latter Order in this respect. Mr. C. J. Gahan, in an interesting paper (Trans. Ent. Soc. Lond. 1891, pp. 367–374), clearly shows that the Phytophagous genus *Diabrotica* is in the same position as the large protected groups of butterflies already mentioned (*Danainæ*, *Ithomiinæ*, *Heliconinæ*, *Acræinæ*). The individuals of its species swarm in the localities where they occur; they are conspicuously coloured, and many of them are known to feign death when captured and to discharge a yellow fluid from various parts. The facts at present ascertained justify the conclusion that these Coleoptera form centres of Müllerian resemblance, in that "some of the species belonging to one section in this genus are, in colour and marking, extremely like certain species of the other section which come from the same localities" (*l. c.* p. 372). Mr. Jacoby has also "recorded that many of the species of his genus *Neobrotica* exhibit most striking resemblances to species of the closely related genus *Diabrotica*." The latter species are also mimicked by those of the allied genus *Dircema*. Mr. Gahan shows, furthermore, that 18 species of the genus *Lema*, belonging to a different sub-family, closely resemble the species of *Diabrotica* (in one case the allied genus *Cerotoma*) found in the same localities in tropical America. In three cases species of *Neobrotica*, and in one a species of *Dircema*, fall into the groups thus formed.

Mr. Gahan is disposed to regard the resemblance of the species of *Lema*, together with that of the Longicorn *Oxylymma gibbicollis*, for a species of *Diabrotica*, as an example of Batesian mimicry. Future observation and experiment must decide upon this as upon so many other cases concerning which we are uncertain whether to adopt the Batesian or the Müllerian interpretation. The tendency of recent observation, however, strongly favours the opinion that the latter theory will explain a much larger number of resemblances than the former.

But whichever interpretation be ultimately adopted, the fact remains the same—that the resemblances in the Coleoptera are of the same character as those in the Lepidoptera, and are, like the latter, independent of affinity. They are readily to be explained by the operation of a theory of selection, but present the same difficulties as those presented by the Lepidoptera to an interpretation by any other theory as yet brought forward.

(6) *The Resemblances in question are not accompanied by any changes in the direction of another Species except such as assist in the production or strengthening of a Superficial Likeness.*

This argument is fatal to any theory as yet advanced except one based upon the principle of selection directed to a definite end, viz. the production of resemblance. It is impossible to explain why external forces or internal forces should thus act upon a certain set of characters whose only relationship is that they tend to produce a superficial likeness to another species—that they should act upon these alone to the exclusion of all other sets. No assistance can be obtained from the conclusion that the results are recent and therefore superficial, and that a resemblance in deeper characters will follow in time. In the first place, the examples of more perfect (and presumably older) resemblance show no more tendency towards approximation in characters which do not help to produce likeness, than the examples in which the resemblance is comparatively rude (and presumably recent in origin). In the second place, deep-seated parts of the organism *are* affected when the superficial resemblance is thereby increased, but not otherwise. To take a single example, the common British Longicorn *Clytus arietis* strongly suggests the appearance of a wasp, partly because of its black and yellow banding, but even more because of its alert and wasp-like movements. This implies, of course, appropriate changes in its nervous and muscular systems.

There are many cases, like that of *Clytus*, in which the changes in deep-seated structures are of more importance than anything else in determining the resemblance. I know of no more striking example of this than the movements and attitudes of the young (Lepidopterous) larvæ of *Endromis versicolor*, which render them extremely like the larvæ of saw-flies (Phytophagous Hymenoptera). Numerous experiments have convinced me that

the latter are almost invariably distasteful. I exhibited the former larvæ in the second stage at the Entomological Society on June 3, 1891. The following account is given in the Proc. Ent. Soc. 1891, p. xv:—"At this period [viz. the early stages of growth] the larvæ arrange themselves in small groups upon the leaves and leaf-stalks of the birch, and when disturbed they raise the anterior part, bending the head over the dorsal surface of the posterior part of the body. In this attitude they strongly remind the observer of those Tenthredo larvæ which, when irritated, bend the tail forwards over the anterior part of the body. The fact that the head is raised in the one, and the tail in the other, does not cause any conspicuous difference when the larvæ are seen from a little distance. The common Tenthredo larva, *Crœsus septentrionalis*, is about the same size as these small Lepidopterous larvæ, feeds in similar small groups when large (when small the groups contain far more individuals), and also frequents the birch." In my experience, however, the *Crœsus* feeds much later in the year. Mr. W. Holland also noted the same resemblance in the 'Entomologist's Record' for Oct. 15th, 1891 (see vol. ii. p. 228). Mr. Holland has also kindly lent me his notes made at the time, and I see that he observed the saw-fly-larva-like movements which follow disturbance. The groups have never been figured before, so far as I am aware. In May 1896 we reared some larvæ from the egg in the Hope Department, and I was able to get some excellent coloured drawings by Mr. P. J. Bayzand. These drawings, reproduced on Plate **40.** figs. 2 & 3, show the attitude taken up on disturbance better than any description. They also prove that, like the saw-fly larvæ, the groups contain far more individuals in the younger stages than later. The conspicuous orange-coloured true legs suggest the appearance of the orange ventral glands of the *Crœsus*, which are everted when the larva is irritated.

Thus the causes of the resemblance we are discussing may be deep-seated or may be superficial, or, more generally, may be due to several kinds of causes in each category. It is in the latter extremely complex cases, and these are far the commonest, that the argument for natural selection becomes irresistible. This will be more thoroughly dealt with in the succeeding Section; but even in the case of the simplest element in the resemblance, viz. the similarity in colour and pattern taken alone, the theories

of external and internal causes are unable to offer an adequate explanation of certain facts which are clearly explicable by natural selection. In the males of the Pierine group *Dismorphina*, the long-and-narrow-winged appearance of an Ithomiine butterfly is largely produced by the excessive overlap of the upper upon the under wings. This results in the concealment of a large part of the upperside of the under and of the underside of the upper wing; and it will be found that the mimetic patterns are withheld from these hidden surfaces, which often retain some distinct trace of the old Pierine character, viz. an opaque white appearance.

The male of *Dismorphia praxinoe* is shown on Plate **40**. fig. 4, the underside in fig. 5; the upper and under sides of the female, for comparison, in figs. 6 and 7. This fact holds true even for such a specialized and perfect mimic as *Dismorphia orise* (see Plate **40**. figs. 8 & 9, for the appearance of the male).

F. D. Godman and O. Salvin, in the 'Biologia Centrali-Americana' (Rhopalocera, p. 173), speak of these hidden chalky patches, surrounded by a silky area covered by peculiar scales, as a character of the *Dismorphina*. The interpretation of the patch as a sexual brand perhaps with the nature of a scent-producing organ, does not in any way disprove the suggestion here adopted—that the white pigment in the scales is a survival from an ancestral condition still found over the greater part of the wing-surface in so many non-mimetic *Pierinæ*, as well as in the males of many mimetic species (*e. g.* in the genus *Mylothris*). It should be noted, however, that the patch is not white in certain species of the *Dismorphina*. Mr. Belt ('Naturalist in Nicaragua,' pp. 384, 385) states that the white patch is usually concealed by the males, as indeed may be inferred from the change in character of the surface, which indicates the normal amount of overlap of the fore upon the hind wing. Mr. Belt also suggested that the white appearance is ancestral and has been retained by the operation of sexual selection.

The restriction of the effects to those parts of the surface which can be seen tells very strongly against any theory which is not based on the principle of selection.

(7) *Essential Nature of these Resemblances: their Analysis into the several kinds of Effect produced.*

The resemblances under discussion are made up of elements

of very different kinds combined in single individuals; but the essentially composite nature of the effect easily yields to analysis. Some of these complex combinations only require to be stated in order to show the inadequacy of the theory which is most usually substituted for natural selection, viz. the theory of external causes.

A mimetic appearance is commonly made up of (1) colour, including (*a*) structural as well as (*b*) pigment colours; (2) pattern; (3) form; (4) attitude; (5) movement.

It may be plausible to hold that direct local influences determine colour, but the case becomes much more difficult when structural tints are included, as they frequently are. Thus it might well be held that the dark pigment of a female *Hypolimnas* and of the *Euplœa* which it resembles are alike the direct effect of the locality they both inhabit. But the most convinced advocate of direct local causes would probably hesitate to explain, by the operation of the same forces, the structurally caused blue sheen which overspreads the dark pigment in some of these mimetic pairs. Similarly with pattern, it is much more difficult to understand the appropriate arrangement of the colours by direct forces than the production of the tints themselves; still more difficult to understand how such forces could modify shape, and again, more difficult to modify the nervous and muscular systems so as to produce appropriate attitudes and movements. Most difficult of all to understand, except on a theory of selection, how the several elements in the complex set of changes could be kept in their proper relationship and guided to a definite end, viz., the production of a superficial resemblance to another species.

The objection to the theory of internal causes is not that it is inadequate to produce each of the effects, but that it is in the highest degree improbable that so complete and harmonious an effect could be frequently produced accidentally by the combination of such diverse elements.

When, therefore, it is argued that these resemblances are the uniform result of uniform forces peculiar to the locality, investigation proves that the results are very far from uniform. They appear at almost any point in the structure of the body, superficial or deep-seated, generally at many points in a single individual both superficial and deep-seated, and the only common bond which can be established between the various elements

which make up the common effect is that they all co-operate in producing superficial resemblance to some other species.

It is here shown that the changes wrought in a single species are far from uniform. It will be shown later on (see Sections 11 and 12, pages 585 to 602) that there is frequently no uniformity in the methods made use of by mimic and model, nor any uniformity between the various mimics of the same model, nor between the different members of a synaposematic group. These, too, often have only one thing in common, and that inexplicable except on a theory of selection, viz. the subordination of all these divergent methods to a single end—the attainment of a superficial resemblance.

The arguments in this and the preceding Section are equally powerful in support of the interpretation of protective resemblances as due to natural selection.

Again, mimetic resemblances are comparatively rarely seen in more than one stage of insect life, and are, in the great majority of cases, restricted to the final stage. In all such species the total appearances presented by the final stage, including mimetic resemblances, are prepared for in the earlier stages, and especially the larval. Not only are the changes in question confined, as has been pointed out in the earlier parts of this Section, to the parts, tissues, and organs which affect the superficial appearance, but they are also generally confined to the final stage of insect life. During larval life the foods peculiar to the locality are devoured and the material for the mimetic stage is stored up. The larval and pupal stages are together, in the great majority of cases, far longer than the imaginal stage, and are no less, and, as regards food, far more, subject to the direct action of the forces peculiar to the locality. On what theory except natural selection is it possible to explain the rigid limitation of these changes, in so large a proportion of cases, to the final stage, and their entire exclusion from the stages in which they are, in the history of the individual, predetermined?

(8) *Conditions of a Species in any Locality are chiefly determined by its Habits and Life-history.*

In the last Section it was shown that there is no uniformity in the effects produced in any locality. In this Section it will be made clear that there is no uniformity in the forces which, by

their uniformity, are supposed to produce the effects. When we are told that common food, common climate, &c. produce a common effect, we have the means for proof or disproof in, at any rate, some striking examples; for we know the food and conditions of certain species which exhibit mimetic or common warning associations. There are many examples of Longicorn beetles mimicking *Lycidæ* (Malacoderm beetles) in the same locality; but during the earlier stages, in which the appearance of the final stage is determined, the former lives in a burrow, feeding upon wood or the tissue of plant-stems, and sheltered from many of the climatic influences and changes, while the other lives in the open, freely exposed to them all, and sustained by an exclusively carnivorous diet. I owe this suggestive comparison and the Section which arose out of it to a conversation with Mr. C. J. Gahan, of the British Museum. Similarly in the case of S. American moths belonging to the *Castniidæ*, which resemble Ithomiine butterflies (see Section 12, page 598), the larvæ of the former burrow in plants, while the latter are freely exposed on the leaves which form their food.

It is hardly necessary to insist on the importance of the *larval* stages in this respect. When the imago emerges from the pupa and its expanded wings have dried, it has assumed its permanent appearance, and nothing that it will eat or endure henceforward produces any further effect upon its colours or patterns, &c. Hence identity of food and conditions during the final stage cannot be of any assistance in the interpretation of mimicry. It is necessary to point this out clearly, inasmuch as Beddard ('Animal Coloration,' London, 1892, p. 232, footnote) has said, speaking of the resemblance between *Eristalis*, the drone-fly, and the hive-bee, "It is an interesting fact, in connexion with the resemblance between this fly and a hive-bee, that it feeds upon pollen and honey. This fact *may* have some significance in relation to the effects of food upon form and coloration." But the larva of *Eristalis* stores up nutriment, out of which the final form is built, by feeding on putrefying animal matter, a food as different as possible from that provided for the larval bee. The peculiar conditions under which the larvæ of stinging Hymenoptera obtain their food invariably contrast strongly with the larval condition of their numerous mimics. We find in this Section, as in the others, that the suggested interpretation of these resemblances as the common effect of a common cause or set of

causes breaks down the moment it is analysed. The view is a superficial one, and cannot be sustained when the slightest attempt is made to understand the nature of the phenomena it professes to explain.

(9) *Mimetic Resemblance and Common Warning Colours more characteristic of the Female than the Male Sex.*

These resemblances are far commoner in females than males, and when the two sexes differ in the closeness with which a likeness to some other form is brought about, it is the female which always attains the greater perfection. Examples of mimetic females with non-mimetic males are extremely abundant, being in fact a high proportion of all the cases which occur; examples of the converse relationship are very nearly unknown. These general statements hold with common warning colours as well as with truly mimetic species; they are equally true in all the warmer parts of the world where examples of mimicry are well known and abundant.

In the numberless cases in which a non-mimetic male is attended by a mimetic female, the former bears the ancestral appearance, so that when we pass to a land where both sexes of the representative species are non-mimetic, *both* resemble the non-mimetic male of the former species. In a long series of related species, moreover, the males are found to be nearly alike, while the females diverge in all directions after the species which serve them for models. Furthermore, the females, by reversion, are in rare instances brought back towards the ancestral type represented by the males.

It is hardly necessary to point to examples, for these general principles will probably be at once conceded by any who have made a study of the subject. I may, however, allude to the non-mimetic *Papilio meriones* of Madagascar and the related forms with similar males but widely different mimetic females on various parts of the mainland of Africa; to the general resemblance between the males of so many forms of *Hypolimnas* of the *bolina* group to each other and to those of *H. misippus*, &c.; to the varying degrees of reversion towards the appearance of the male presented by occasional females of *Hypolimnas bolina*.

These relationships are the reverse of those which usually

obtain. Outside these resemblances it is the rule, when any difference between the sexes exists, for the female to show us the ancestral type, the male the more modern development; and the male in growth from youth to maturity generally passes through the condition permanently retained by the female.

No probable interpretation of these unusual relationships can be offered by any theory except natural selection. The theory of external causes demands the improbable hypothesis, for which no evidence can be found, that the female of mimetic species (but not of others) is constitutionally more ready to respond to the direct action of external forces than the male, and that the difference is commonly great enough for the female to have given a complete and detailed response, when the male, subject to the same direct forces, does not exhibit the faintest trace of the operation of any such influence.

The facts are equally inexplicable by the theory of internal causes—and not inexplicable only, but the reverse of what we should expect; for, as I have already stated, it is the female which, outside these resemblances, tends to retain the ancestral form.

The theory of sexual selection also fails to account for the facts. If it were valid, the selection would be that of the male, for these recent developments are specially characteristic of the other sex. In other cases in which male rather than female selection is supposed to have acted in the production of colour or pattern in butterflies, there is some direct evidence derived from the observation of courtship; but here no such support is forthcoming.

Under the theory of natural selection the facts at once receive an explanation. Wallace suggested long ago that the slower flight of the females "when laden with eggs, and their exposure to attack while in the act of depositing their eggs upon the leaves, render it specially advantageous for them to have some additional protection." In animals which are hidden by protective resemblance, similar causes explain why the female is so often better concealed than the male. In birds the dangers of incubation balance the dangers of egg-laying in insects. But protective resemblances are less special than cases of mimicry in the sense that the models (bark, twigs, leaves, &c.) are more generally alike throughout all countries, and less rapidly change their distribution than the models of mimicry and

the dominant types of common warning colours. These and other reasons, such as the great number and wide geographical range of species belonging to the same genus and adopting a single method of concealment, compel the belief that examples of protective resemblance are extremely ancient in the past history of the species as compared with examples of mimicry, so that we can well understand how it is that in the former, when the female differs it is ancestral as compared with its male, while in the latter the converse relationship obtains, and the appearance presented by the male is comparatively ancestral.

The main conclusion which emerges is that the advantageous is the thing that is attained. If an ancestral appearance is advantageous it is retained, especially in the sex that needs it most: if a new appearance is advantageous it is attained, especially by the sex that needs it most. The female sex becomes conservative or progressive according to the needs of the species, and natural selection is limited by no bounds of constitutional difference between the sexes as regards the preservation of the old or the initiation of the new.

(10) *The Space and Time Relationships of the Resemblances in Question.*

A mimetic group is found in the same locality, or at least the mimic (Batesian) is not found beyond the range of its model. The types of Common Warning Colours are remarkably local, although probably certain members of the group (being *ex hypothesi* all specially protected) may sometimes have a wider range than others. When such a mimic as *Hypolimnas misippus* can invade and thrive in South America and the Antilles in the absence of its model (*Limnas chrysippus*), we probably have to do with a Müllerian rather than a Batesian association (see also a paper on Mimicry in the Genus *Hypolimnas* by E. B. Poulton in Report Amer. Assoc. for Adv. of Sci., Detroit Meeting, 1897, where other arguments in support of this conclusion are urged).

Looking at the examples broadly the phenomena are characteristically local. This, although harmonizing with the other suggested explanations, is quite unintelligible if the theory of internal causes be adopted. Why should these results if attained independently in the evolution of various forms be attained in the same locality? The number of patterns and the number of forms is so vast that we must expect a certain amount

of accidental resemblance due to internal causes, as has been suggested by Beddard ('Animal Coloration,' London 1892, p. 252); but such resemblances will differ from those under discussion in this among other things—that they will not be characteristically local. The theory of internal causes offers us a valid interpretation of such cases, which are, as a rule, readily distinguished from those which are here considered.

There is another aspect of locality which only receives an explanation on the theory of natural selection. Why should examples of mimicry and common warning colours be so much more abundant and perfect in one country than another? The physico-chemical influences, the effects of luxuriant vegetation, as Wallace has pointed out, are very similar in tropical S. America, Malaya, and W. Africa, and yet the first-named country is pre-eminent in affording examples of the resemblances under consideration. This is not only true of likenesses within the Order of Lepidoptera, it appears to be equally true within the Coleoptera; it is true of the resemblances of moths to wasps. It is even more marked in Müllerian resemblance between protected forms than in the examples of Batesian mimicry. If the direct action of forces connected with locality cannot explain the immense predominance of tropical South America in this respect, we are driven to enquire whether insect-life is especially luxuriant and remarkable in this part of the world, and whether it is not probable that the struggle for existence is especially keen. There is no doubt about the answer to the former question; the variety, peculiarity, and abundance of insect life is far greater than in any other part of the world, and it is a fair inference that the conditions are in an equally marked degree favourable for rapid and complete modifications under the operation of natural selection.

We have not as yet sufficient evidence that mimetic groups and groups with a common warning coloration appear at the same time of the year. Such evidence as we have points in this direction. The rarity of the mimetic species is usually stated to be due to their being lost in the swarms of the abundant model. There are a large number of cases in which the forms have been caught together by a collector who has passed a limited time in a given locality.

We are collecting at Oxford as many examples as possible of such species, captured upon the same day in the same place.

This series, which we intend to keep separate, when more complete, will afford very valuable evidence on this point. Already it proves that the members of the groups which converge round *Limnas chrysippus*, *Amauris echeria*, and the black and white species of *Amauris* in Natal are upon the wing together. This evidence has been very kindly supplied me by Mr. Guy A. K. Marshall. I have similar, but less complete, evidence as regards some of the Central and S. American groups.

It will probably be conceded that the phenomena generally are likely to exhibit the same relationship in time which has been already proved to exist for many of them. This conclusion, however, is a considerable difficulty in the way of the theory of external causes as well as a further difficulty to the theory of internal causes. As regards the latter, the time relationship is an entirely unexplained coincidence ; as regards the former, it is a coincidence which leaves much to be explained. It is difficult enough to believe that local forces could produce local resemblance ; it is a further difficulty that the resemblances are contemporaneous. If, as is probable, the forces are supposed to act during larval life, they must include in their effects an influence on the rate of growth and development, an adjustment of the duration of stages delicate enough to bring the various species into the phases in which the resemblance is shown at similar times of the year. But such effects are entirely different from those which are manifest in the resemblance itself, and add a further complexity to a result already shown to be so complex that the theory of external causes fails to supply an interpretation (see Section 7, p. 576).

But it has been shown in many cases, and is probably true in all, that the time relationships between the species which exhibit these resemblances are not confined to their appearance at the same season of the year. They are such that they fly together under those conditions of light which render the resemblance visible to enemies. When moths resemble butterflies, they are mostly species which are as truly day-flying as the butterflies themselves ; in other cases they are species which fly readily by day when disturbed. Similarly with the species of various orders which resemble Hymenoptera. The case of Coleoptera recently suggested to me by Mr. Gahan is peculiarly interesting. It is known in so many cases that beetles which are about by day possess finely facetted eyes as compared with the larger fewer

facets of the nocturnal species, that it is possible to infer the habits from the structure of the eyes. Thus the species of the Longicorn genus *Doliops* (family *Lamiidæ*), which closely resemble weevils (see p. 596), are, judged by this standard, diurnal in their habits. The case is all the more interesting, inasmuch as such an eye-structure, such habits, and such mimicry is quite exceptional in the group, the *Niphoninæ*, to which the genus belongs.

The facts recorded above imply such a resemblance between the nervous systems and sense-organs of the various species as will make them diurnal (or in some cases semi-diurnal) in their habits. This constitutes a further grave difficulty in the way of any explanation based on external or internal causes. If the diurnal habits are supposed to be due to such causes, the vastly increased complexity of the result is the difficulty. If the resemblances are supposed to be thus produced only in the species which are already diurnal, it is impossible to explain why the external or internal forces are thus restricted in their operation.

It is hardly necessary to point out that the time and space relationships, which are such a difficulty in the way of the other two theories, are entirely necessary to the explanation based on the theory of natural selection. If they did not exist it would be overthrown.

(11) *The Resemblances which Insects of various Orders bear to those of another Order are produced in the most Diverse Ways.*

The most common types for mimetic resemblance are those of the wasp and ant. These aggressive, abundant, and successful forms are resembled by insects of various orders. Still more interesting is the fact that the resemblance is produced in the most varied ways.

A superficial resemblance to stinging Hymenoptera is probably more general and is brought about by smaller changes in Diptera than in any other Order of insects. A fly which gains alternate black and yellow rings on its body is at once suggestive of an appearance presented by many common wasps. In more extreme cases, the body gains a constriction presenting a strong likeness to the slender petiole of the wasp's abdomen, there are changes in the manner of folding and sometimes in the colour of the wings, in

the buzz, in the movements of the body (the latter being such as to suggest the power of stinging), and (in the mimicry of hairy humble-bees) in the acquisition of an abundant hairy covering. A good example of a fairly perfect resemblance is shown in Plate **41.** fig. 5 A, an Australian fly, the models from the same part of the world being shown in figs. 5 B and 5 C.

A Hemipterous insect requires the most profound modification in the shape of its flattened un-wasp-like body, and in the display and characteristics of its wings. Corresponding to these much greater initial differences, the resemblance is *much* rarer than in Diptera. A beautiful instance is shown in Plate **41.** fig. 1, a Hemipterous insect—a species of *Myocoris*, probably *M. braconiformis* (Burm.)—which is extraordinarily like fig. 2, not, in this instance, a wasp but an ichneumon, using the term in the broad sense; for the species belongs to the *Braconidæ* and is probably an *Iphiaulax.* Although the two specimens in the British Museum, which I have been kindly permitted to figure, did not come from the same part of S. America (the Bug was from Para, the Ichneumon from Ega), the resemblance is so close in every way and the modification of the Hemipteron so extreme and remarkable, that there can be little doubt as to this being a genuine case of mimicry and as to the geographical coincidence of the model and mimic: both may have a far wider range than is shown by the specimens which have been figured*.

A Lepidopterous insect requires above all to gain transparent wings, and this in the most striking cases that have been studied is produced by the loose attachment of the scales, so that

* Since the above sentence was written I have searched the collections in the British Museum for further examples, with the help of Sir George Hampson, Mr. C. J. Gahan, and Mr. W. F. Kirby. We found that the type of appearance represented in Plate **41.** figs. 1 and 2 is common and widely distributed in S. America, forming a group which includes many species of *Braconidæ* and of Hemiptera which resemble them. Many figures of such insects presenting this type of appearance are to be seen in the plates of the 'Biologia Centrali-Americana.' In the distasteful group of moths, the *Syntomidæ*, two species are obviously similar, viz., *Leucotmemis varipes* (Walk.) from Para, and *L. tenthredoides* (Walk.) from Ega. *Myocoris braconiformis* is recorded from Surinam as well as from Para.

The co-existence of species of Aculeate Hymenoptera, Hemiptera, and distasteful Heterocera, suggests that the group as a whole is distasteful or specially protected, and is an example of common warning colours. Many other members of the group will probably be recognized

they easily and rapidly fall off and leave the wing bare except for a marginal line and along the veins (*Hemaris*, *Trochilium*). In other cases again (certain *Sesiidæ*) the scales may remain on the wing, but themselves become transparent. In the numerous more perfect instances the body is banded, and may gain a marked "waist," while the scales upon it may be lost or modified, so that the appearance of the hard shining body of the model is suggested with extraordinary exactness.

The means adopted among Coleoptera, even in closely related genera, are so curiously different that a longer description, accompanied by several illustrations, is necessary.

The following examples are all selected from the Longicorns. The simplest resemblance to a wasp is that attained by the common beetles of the genus *Clytus*, such as the British *C. arietis*. A better example is the Mediterranean species *Plagionotus scalaris*, shown on Plate **41**. fig. 3. In these cases there is nothing visible to represent the wings of a wasp; but the elytra and thorax are black banded with yellow, there is a far more pronounced "waist" than is usual in Coleoptera, the legs are slender and wasp-like, and are moved with wasp-like activity and jerkiness. In spite of the apparent want of wings, the effect produced is very considerable, and many persons hesitate to touch the insect. This, then, is the method adopted in the group of *Clytinæ*; but in various other allied tribes, such as the *Necydalinæ*, the *Rhinotraginæ*, the *Esthesinæ*, the *Callichrominæ*, and others, the elytra, which form by far the largest part of the visible dorsal surface in the *Clytinæ*, become greatly reduced so as to show the under wings, which, folded over the back or expanded in flight, in either case strongly suggest the wings of a wasp, or in some cases an ichneumon. Furthermore, the elytra are reduced in two different ways—in some genera to linear rudiments more or less broadened at their bases; in others to small subquadrate or oval structures representing the bases alone. Good examples of the latter are seen in *Esthesis ferrugineus* (*Esthesinæ*) (Plate **41**. fig. 5) from Australia, and in *Nothopeus hemipterus* (*Callichrominæ*) from the Oriental Region (see fig. 4). Examples of the former are shown in *Isthmiade braconoides* (*Rhinotraginæ*), fig. 6, from Brazil, and in a *Hephæstion* sp. (*Necydalinæ*), fig. 7, from Chili.

The examples figured are merely a few selected from a large number, but they serve to show the different degrees to which a

mimetic resemblance is carried, and the very different methods employed, in a nearly related set of insects.

The Hymenoptera, which form the models of these insects, have not been worked out in many of the instances. In the case of *Esthesis ferrugineus*, however, two Aculeate Hymenoptera of very different form, although belonging to the same large group—the *Eumenidæ*, which inhabit the same region (Australia), have a colouring and pattern which are superficially very similar to those which the Longicorn has attained; while a Dipterous insect, an Australian species of *Dasypogon* (*Asilidæ*), also appears to fall into the group. The appearance of the three latter insects is represented in Plate **41**, the dipterous insect being shown in fig. 5 A, the wasps in fig. 5 B, *Abispa australis* (Smith), and fig. 5 C, *Eumenes Latreillei* (de Sauss.). These three figures were drawn from specimens in the British Museum, kind permission having been accorded to me to figure them for the purpose of this memoir. Future study will probably add many species to this very characteristic group.

We thus find that wasps and allied forms are resembled by species of many groups of insects, and the resemblance is attained in all kinds of different ways.

The numerous mimetic resemblances to the aggressive, abundant, and well-defended ants supply an even better illustration. In the majority of cases the whole body of the mimetic form is moulded from the ancestral shape, which is still exhibited by its non-mimetic allies, into that which is characteristic of an ant. In some groups this means a large amount of alteration, in others less. In this case, too, the resemblance extends to species which are altogether outside the Insecta; for many small species of spiders closely mimic ants. In the family of *Attidæ* alone, and such resemblances occur in several other families of spiders, George W. and Elizabeth G. Peckham state (Occasional Papers of the Natural History Society of Wisconsin, vol. ii., 1892, Milwaukee; see also a paper by the same authors in vol. i., 1889) that about a hundred ant-like species are known from various parts of the world, and that they are "very much more numerous in South America and in the Malay Archipelago than in any other countries," viz. in the very countries in which other examples of mimicry are especially abundant. The spider with its two-fold division of body is often made to assume the appearance of an ant, with its three-fold division, by a constriction which

sometimes crosses the cephalothorax, sometimes the abdomen. The absence of antennæ in the spider is known to be compensated in some of the species, which have been studied in the living state, by the habit of holding up one pair of legs, while the walking legs are thus reduced to the ant-like number of six. Of two well-known North American species, *Synageles picata* holds up the second pair, and *Synemosyna formica* the first. The habits of seizing and dealing with prey, and the movements generally are extremely un-spider-like and most suggestive of ants; so that the nervous and muscular systems, as well as the body-form, have been modified. The remarkably ant-like appearance of these two species is shown in the adjoining fig. 1 (A and B).

Fig. 1.

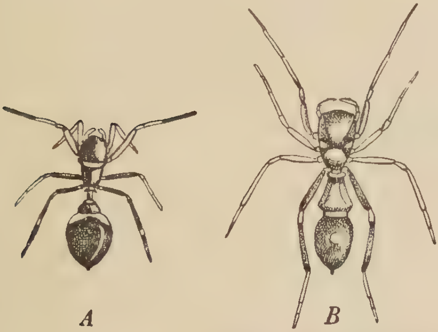


Fig. 2.

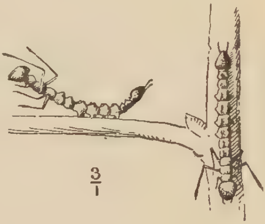


Fig. 1.—Two North-American Attid spiders which resemble ants. A is *Synageles picata*; B, *Synemosyna formica*. (From G. W. and E. G. Peckham, Occasional Papers of the Nat. Hist. Soc. of Wisconsin, vol. i. 1889, pp. 110 & 112.)

Fig. 2 ($\times$ 3).—The young larva of *Stauropus fagi* seen from above and from the left side.

Among the Insecta, too, there are many examples of an ant-like appearance brought about by changes of the same kind as those mentioned above, although less marked because the forms to be approximated are less essentially different. Among the Lepidoptera the young larvæ of a British moth, *Stauropus fagi*, have often been described as resembling ants. The likeness has recently been analysed in much detail by Portschinski (“Coloration marquante et Taches ocellées,” V.: St. Petersburg, 1897, p. 44). This acute observer considers that the head of the

larva represents the globular abdomen of the ant, while the head and antennæ of the latter are suggested by the larval caudal shield with its two appendages. He believes that the disturbed larva represents an ant which has seized and is endeavouring to carry off some object on the branch which it is exploring. Under these circumstances the head of the ant, with its mandibles fixed in the object, would be held low and remain motionless, while the abdomen would be elevated and the legs in constant activity, moving the posterior part of the body from side to side. Such an appearance and such movements, he maintains, are strongly suggested by the disturbed larva if we only identify the posterior end of the one with the anterior end of the other, and *vice versa*. I have to thank Mr. W. R. Morfill for very kindly translating the memoir of the Russian naturalist. During the present summer (of 1898) I have had the opportunity of studying these larvæ. The young larvæ were thought to be ants by all the friends to whom they were shown. One lady considered that they were "double ants"—an interpretation evidently due to their disproportionate length and to the head-like appearance of the caudal shield. Drawings of the larvæ at this stage were made by Mr. P. J. Bayzand and are reproduced in fig. 2 (p. 589), but they fail to convey the ant-like appearance which depends so largely on movement. A better effect is produced by Mr. Bayzand's coloured drawing which is reproduced on Plate **40**. fig. **1**. I should add that I did not observe any attitudes which support the details of Portschinski's interpretation, nor did I witness the appearances which he figures (*l. c.* p. 45, fig. 21). His comparison of the caudal appendage with a head seemed, on the other hand, to be entirely confirmed.

Turning to other Orders which supply examples of the mimicry of ants, the Hemiptera have perhaps the farthest distance to travel in the modification of their flattened bodies. A beautiful example from East Africa, viz. that of *Myrmoplasta myra* (Gerstaecker), is shown in fig. 3. Gerstaecker states that a single specimen of this insect was sent from Rosako, Usaramo, Aug. 1888, as "an ant," together with two undoubted species of these Hymenoptera (*Polyrhachis gagates* and *Ponera tarsata*). The resemblance between the former species of ant and the Hemipteron, Gerstaecker describes as strong enough to be deceptive. It is brought about, he states, by the short globular abdomen extremely constricted towards the thorax

Fig. 3.

Fig. 4.

Fig. 3 (× 3).—An ant-like East-African Hemipterous insect, *Myrmoplasta myra* (Gerst.), seen from above and from the left side. (From Gerstaecker, Article 6, Hemiptera, p. 9, in Fr. Stuhlmann's Zool. Ergeb. 1888–1890, Berlin 1893.)

Fig. 4.—An ant-like N.-American beetle, *Euderces picipes* (Fab.), seen from above and from the right side.

(Zool. Ergeb. einer Reise in Ost-Afrika, Fr. Stuhlmann, Bd. I. no. ix. 2; Article 6, Hemiptera, p. 9: Dietrich Reimer, Berlin, 1893).

Among Coleoptera the resemblance to ants is very common. I select as an example a little Longicorn (*Euderces picipes*, Fab.), which I found very abundantly upon the heads of Umbelliferous plants at Pine Lake, Hartland, Wisconsin, in July and August 1897, when visiting Dr. C. A. Leuthstrom. Ants were also very common on the same flower-heads. The appearance and movements of the beetles were extremely ant-like, the suggestion of a stalked abdomen being conveyed by an oblique white line crossing the elytra in a very shallow depression in which the dark ground-colour of the insect appeared to be of a more intense black than elsewhere. The increased darkness was in reality

due to the shadow in the depression combined with the effect of a difference in the texture of the surface. This combination of characters produced a strong superficial resemblance between the elytra of the beetle and the abdomen and thorax of the ant, while the head of the latter was represented by the beetle's head and thorax together. These resemblances are indicated in fig. 4; but the living insect is required in order to recognize them fully.

In all the cases alluded to above, the resemblance is attained by a modification in the form of body and limbs, accompanied by changes in those more deep-seated structures which affect the habits and movements.

There are, however, other very different means by which the same end is attained. One of the most interesting of these is the case of a Locustid (*Phaneropterides*), *Myrmecophana fallax* from the Sudan, described by Brunner von Wattenwyl (Verhandl. der k.-k. zool.-botan. Ges. in Wien, 1883, p. 247). This insect was erroneously described as an Acridian in my paper before the British Association at Toronto (Report, 1897, p. 693, l. 3). Brunner's two figures are reproduced as the adjacent fig. 5. Upon the stout body of this insect the slender-waisted form of an ant is represented in black pigment, the remainder of the body being light in colour and probably invisible against a similar background. Of the habits of the insect nothing is known, but the method is of great interest, being so entirely different from that adopted by any other insect as yet described. In a more recent work ('Observations on the Coloration of Insects,' English translation by E. J. Bles, Leipsic, 1897, p. 11), Brunner von Wattenwyl again alludes to this example, and states that the form of the species "leads to the conclusion that it lives on the ground," viz. in the position which gives a meaning to the resemblance. In spite of this he asks, "Is this imitation an accidental freak of nature?" If *Myrmecophana* were the only example of such resemblance the question might fairly be asked, but in view of the numerous other equally close resemblances to ants, produced in various ways, it is quite unnecessary. The suggestion of an "accidental freak" can never explain such close likeness, in appearance, in movements and habits (so far as they are known), in locality—a likeness, furthermore, not to any insect in the environment, but to insects of a specially successful and aggressive group—a likeness not produced in one way but

in many different ways. To suggest an "accidental freak" as the explanation shows an amazing credulity, only to be explained by the bias which is ready to accept ANY interpretation except that afforded by the theory of natural selection.

Fig. 6.

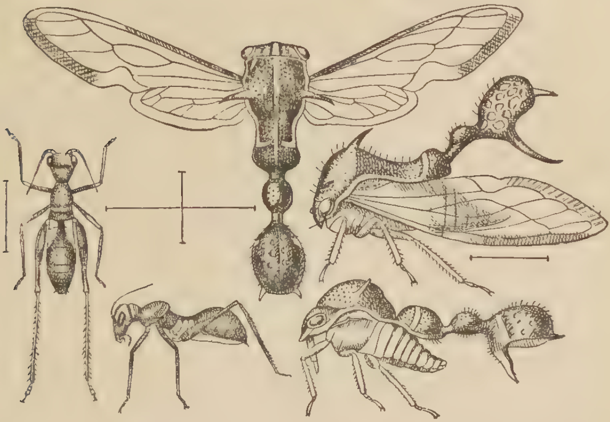


Fig. 5.

Fig. 5.—A Locustid from the Sudan, *Myrmecophana fallax* (Brunner), seen from above and from the left side. On this insect the appearance of an ant is represented in black pigment, all other parts being light in colour and presumably concealed. (From Brunner von Wattenwyl, Verhandl. d. k.-k. zool.-botan. Ges. in Wien, Bd. xxxiii. 1883, pl. xv. figs. 1 *a* & 1 *b*.)

Fig. 6.—A Central-American Membracid (Rhynchota Homoptera) in which the prothoracic shield resembles an ant. Thus the body of the insect which is not like an ant is concealed by an ant-like shield. The species is *Heteronotus trinodosus* as seen from above and the left side. The upper of the two figures seen from the side represents a female, the two other figures, males. (From W. W. Fowler, Biol. Centr.-Am., Rynch. Homopt. vol. ii. pl. 6. figs. 16, 16 A, & 17.)

Another and equally interesting method is adopted by certain tropical American Rhynchota Homoptera belonging to the family *Membracidæ*. In this remarkable group the dorsal region of the first thoracic segment (the pronotum) is of enormous size, extending upwards and backwards so as completely to cover the insect with the exception of the head, limbs, and wings. What natural selection effects in the general body-form of other insects, must here be effected, if it is to be of any value, in the shield which is seen, and not in the body which is concealed.

This change has been brought about, and certain species of the group have their un-ant-like bodies concealed under an ant-like shield. In other species the prothoracic shield is modified into a resemblance to other objects, such as seeds, thorns, &c.—an excellent example of the parallelism between mimetic and protective resemblance insisted on on page 565. The effects produced in the shield are at least as exact and detailed as those which in other cases are wrought in the form of the whole body; for, as Mr. W. F. H. Blandford has pointed out to me, a peculiar characteristic of certain tropical American ants (viz. the bead-like dilatation in the stalk of the abdomen) is reproduced in the shield of the membracid. This is well seen in *Heteronotus trinodosus* shown in fig. 6, copied from Canon W. W. Fowler's Monograph of the group in the 'Biologia Centrali-Americana.'

Finally, in the same group of *Membracidæ* we meet with another example which is also incapable of interpretation by any theory as yet brought forward except natural selection. An immature form of membracid, with the prothoracic shield not yet formed, found by W. L. Sclater in British Guiana, strongly resembles one of the leaf-carrying ants which are so common in that part of the world; but the resemblance includes the leaf as well as

Fig. 7.

Fig. 7.—About three times the natural size. On the right is represented an immature Membracid (Rhynchota Homoptera) from British Guiana, which resembles an ant together with the leaf it is carrying. The latter is shown on the left, and represents the species *Œcodoma cephalotes* from the same locality. (From Poulton, Proc. Zool. Soc. 1891, pl. xxxvi. fig. 2.)

the ant! The dorsal region of the membracid is flat and compressed, so that it is as thin as a leaf; its border (the dorsal surface, which formed a sharp edge) is jagged like a gnawed leaf, and during life it was green in colour. Beneath this leaf-like

expanse the brown head and legs of the insect were visible just as, in the case of the ant, they appear beneath the piece of leaf which is carried vertically between the mandibles and thrown over the back. This example was described by the present writer in Proc. Zool. Soc. 1891, p. 462. The appearance of the membracid and leaf-carrying ant is seen in fig. 7, which is reproduced from the paper just mentioned. It is possible that certain species of the Orthopterous genus *Tettix* (*Acridiidæ*) also resemble ants carrying leaves.

It would of course be ridiculous to ascribe this last resemblance to any direct external forces connected with locality, or to any internal forces, independently producing a like result, and, as the species was in an immature condition, it is equally impossible to invoke the aid of sexual selection.

Natural selection remains as the only feasible interpretation.

Even more striking than this remarkable example is the contemplation of all these various methods and their relation to each other. The means by which the resemblance to ants are brought about are diverse, the end—the resemblance itself—is uniform. Furthermore, the likeness is almost always detailed and remarkable, however it is attained, while the methods made use of differ absolutely. Such a result, it would seem, is the most complete proof of the operation of natural selection that can be attained, short of the actual demonstration of its action by observation and statistics. If this argument be confirmed by a study and comparison of the foregoing figs. 1 to 7, I venture to think that it will meet with general acceptance.

When one insect resembles an ant by the superficial alteration of its whole body-form, another by the modification of a shield-like structure which conceals its unaltered body, another by having the shape of an ant painted, as it were, in black pigment upon its body while all other parts are concealed; another by a further modification of its body, so that it represents not an ant only, but the object which the ant is almost always carrying,—when the effect of all these results is heightened by appropriate habits and movements, we are compelled to believe that there is something advantageous in the resemblance to an ant, and that natural selection has been at work. The phenomena do not merely disprove all other suggested causes of change, but they constitute the most powerful indirect proof of the operation of natural selection.

(12) *The Resemblances within the Limits of the Order are also produced in the most Diverse Ways.*

Illogical as I believe the position to be, it is quite possible that many observers may concede the force of the argument concluded above, and yet continue to hold that the resemblances within the Order are produced by external or perhaps by internal causes. It can however be shown that the same condition is true in the more restricted group as was found to apply to the wider. Even within the Order itself resemblances are produced in very diverse ways, although minute examination is sometimes necessary before the essential difference which separates them can be revealed.

Certain Longicorn beetles resemble weevils, the *Curculionidæ* being, so it is believed, specially defended by their extremely hard chitinous covering. The weevils closely resembled by such Longicorns as *Doliops curculionoides* and *D. geometrica* have short antennæ ending in a knob. The antennæ of the *Doliops* are nearly three times as long; the resemblance to the weevil being produced by a dilatation of the third joint, which represents the knob, while all the joints beyond are of such excessive fineness that they are almost invisible. The strong resemblance of the Longicorn *Estigmenida variabilis* to *Estigmena chinensis*, belonging to the *Hispidæ* (Phytophaga), is brought about in a similar manner, as was pointed out by C. J. Gahan. In this case about one third of the length of the Longicorn's antenna is concealed by its extreme fineness, while the apparent terminal thickening is produced by hairs at the end of the thicker section.

In these examples, kindly shown me by Mr. Gahan, neither the theory of external nor that of internal causes is of any avail. It is impossible to believe that the resemblance is a direct effect of climatic or other forces connected with locality, when the results are in reality so utterly different and yet superficially so entirely alike. The fact which requires explanation is the extraordinary likeness in spite of the essential difference, and this, when it is repeated again and again, cannot be interpreted by any theory unless based upon the principle of selection.

Many other examples of the same kind could easily be brought forward: in fact, it may be admitted as a general principle that in protective mimicry and common warning colours

the resemblance is *never* attained by precisely similar methods, and generally by methods which are extremely unlike. I propose, in concluding this Section, to discuss a few examples from the Lepidoptera, inasmuch as the resemblances in question have been chiefly studied in this group, and because an explanation based on the theory of external or on that of internal causes has been sought more often and pressed more strongly in the case of the Lepidoptera than in that of any other Order.

The *Pierinæ* are specially liable to take on these resemblances. In tropical America they chiefly resemble the *Ithomiinæ*, *Heliconinæ*, and *Papilioninæ*, affording some of the best and earliest recorded examples of mimicry (although Dr. F. A. Dixey has now shown that they are more probably to be interpreted as common warning colours). The chemical nature of the wing-pigments of the *Pierinæ* has recently formed the subject of an interesting paper by F. Gowland Hopkins (Proc. Roy. Soc. 1894, p. 5, and Phil. Trans. 1895, B. p. 661). The author shows that the white pigment so common in the group is an impure uric acid probably uncombined, that the yellow and orange pigment is a derivative of uric acid to which he gives the name "lepidotic acid," while a much rarer red pigment, less fully investigated, is probably of a closely similar constitution. These three pigments, with black, which is apparently intimately associated with the cuticle of the scales, with a pigment placed between the two laminæ of the wing and with superadded optical effects due to structure, account for the whole of the colouring of Pierine butterflies. No pigment of similar constitution to the Pierine white, yellow, and red, was found by Mr. Hopkins in any other butterfly—not even in the allied *Papilioninæ*. The Pierine butterflies which resemble the *Ithomiinæ* or other butterflies were found by Mr. Hopkins to achieve this end, not by gaining the true pigments of their models, but by means of the characteristic Pierine pigments. The bands of warm red-brown, the spots of white and yellow, which so closely resemble the same tints in the *Ithomiinæ*, are in reality caused by pigments of an entirely different nature—the resemblance, even between the pigments themselves, is wholly superficial.

The argument that the resemblances we are discussing are due to the common result of common forces, is simply an improbable assumption. It has been proved again and again

that the results are not common, the resemblance merely deceptive. And now this has even been shown for the colours themselves, in some of the best known and most striking examples of mimicry.

The last example of similarity in appearance produced through diversity of method is one which occurred to me a few years ago when lecturing on mimicry in the Hope Department at Oxford. It was worked out in detail during the summer of 1897, and the general results were communicated to Section D of the British Association at Toronto, on Monday, August 23rd, 1897. A brief abstract is printed in the Report of the Meeting (pp. 692–694).

Although the Lepidoptera are characterized as an Order by the clothing of scales upon the wings, cases are very frequent in which this covering has been in part, or almost wholly, lost. By comparison with kindred unmodified forms, as well as by microscopic examination of the transparent areas themselves, it is possible to show that this loss is recent, and to trace the steps by which it has been reached from a condition in which normal scales were present.

In the very large convergent group of tropical American Lepidoptera, which has sprung up round the best known species of the Ithomiine genera *Methona* and *Thyridia*, transparency of a large part of the wings is a characteristic feature. Throughout the group the ground-colour of the wings is transparent, with a black border which generally passes inwards as two transverse bands in the fore wing, separating the transparent part into three areas, and as one band in the hind wing, separating it into two areas. The group consists of *Ithomiinæ* (*Neotropinæ*) of many genera, of *Danainæ*, of *Pierinæ*, and of moths of the genera *Anthomyza* and *Hyelosia*, belonging to the *Pericopidæ* (*Hypsidæ*), and the widely separated genus *Castnia* (*Castniidæ*).

Under the theory of external causes we should expect that the transparency would be attained in a similar manner throughout, by the reduction of scales to hairs, by the complete loss of scales, or by some other uniform method. Under the theory of natural selection we should expect that the methods would be different in the different groups. There are many ways in which transparency can be attained, and we should expect that one group would submit one set of variations making towards the resemblance, another a different set, to the operation of

natural selection. It will be shown below that this prediction is abundantly justified.

Although H. W. Bates did not know all the species we recognize now, he knew of all the chief sections of this group, and described them (figuring certain of the species) in his paper published in the Transactions of this Society for 1862. A representation of the group as he describes it is shown in Pl. 42. fig. 1; but he also mentioned another set of rather smaller insects which is really continuous with the other group and should be considered with it. This included the Ithomiine species *Dircenna epidero*, *D. dero*, and *D. rhoeo*, and the moth *Hyelosia tiresia*.

Owing to the kindness of Mr. Godman, Mr. Salvin, and Mr. Herbert Druce, I am able to figure the group as it is now known with over thirty species (Pl. 42. fig. 2). The simple combination of transparency and black which makes up the whole of the appearance of these species renders an uncoloured representation entirely sufficient. The strong general resemblance which runs through this large group is well seen in fig. 2, which is taken from a beautiful photograph of the actual insects made by Mr. Alfred Robinson, of the Oxford University Museum. The arrangement of the insects for the camera upon small pieces of cork glued on to a sheet of glass. was a work involving great care and skill, and in this, as in so many other sides of my work, I wish warmly to thank Mr. W. Holland, of the Hope Department, for his most efficient help and ready kindness.

Microscopic examination of the *Ithomiinæ* (*Neotropinæ*) showed that the scales on the wings are of two kinds, broad and narrow, which alternate more or less regularly. In the transparent parts both kinds of scale can still be detected, the narrow being frequently reduced to fine simple hairs, and, in the most extreme cases, the broad scales being reduced to Y-shaped hairs. The two commonest species of the whole group, probably forming the centre towards which the others have converged, are shown in Pl. 43. fig. 1. These species, belonging to very different genera, afford a good example of the closeness of resemblance which may be attained by common warning colours. The two forms are constantly found intermixed in collections, and superficially are almost exactly alike. Nevertheless, a study of the transparent part of the wing under the microscope reveals the fact that the degeneration of the scales

has reached a very different level in the two species. In this, as in all other instances, the transparent patch at the apex of the left fore wing was selected for study and for photomicrography. Dr. Gustav Mann, of the Oxford University Physiological Laboratory, kindly assisted me in the difficult details of this latter work, and such success as I have been able to attain I owe mainly to him. Fig. 2 shows the structure of the transparent patch in *Methona confusa*; fig. 3 its structure in *Thyridia psidii*. In both the broad scales are reduced to small bifid structures, of a distinctly different form in the two species; while the narrow scales are reduced to long extremely fine hairs in the *Methona*, and to much broader ones in the *Thyridia*. In both the transition into the scales of the opaque part of the wing is well seen on the upper part of the figures. The comparison between the almost identical appearance of the two insects as shown in fig. 1, and their real differences which are seen to be very marked in figs. 2 and 3, affords another good example of the principle which has been already so abundantly illustrated—that when a close superficial resemblance has been attained no further similarity in the details of structure is produced. This is apparent enough even in these two genera belonging to the same sub-family. It is of course illustrated in a far more striking manner when the affinity is much more remote.

We now pass to the *Danainæ* which fall into the group. The *Danainæ* supply it with two species, both belonging to the genus *Ituna*, shown in Pl. **43**. fig. 4. The *Ithomiinæ* were formerly classed with the *Danainæ*, and in any case form the sub-family which stands next to them. But fig. 5 shows that transparency is attained in an entirely different manner, the scales being neither greatly reduced in size nor much altered in appearance. It is the great reduction in numbers which is here the cause of the transparency. The scales retain their dark pigment and produce the effect of a grey dusting over the transparent areas. The transition into the opaque black part of the wing is well seen on the upper part of the figure.

Finally, there is a single species belonging to the distant family *Papilionidæ* and sub-family *Pierinæ*—*Dismorphia orise*. This species is shown in Pl. **44**. fig. 1 together with *Methona confusa*. The upper two figures of the *Methona* and of the *Dismorphia* show a male and female of the type form of each

species, while the lowest figure shows a form which is found in Ecuador. In certain parts of Ecuador the black borders and bands of the *Methona* (recently distinguished as *M. psamathe*, Godm. & Salv.) are much narrower than in the type form, and it is seen that the *Dismorphia* from the same locality has followed in the same direction. This interesting parallelism was pointed out to me by Mr. Salvin, and is here illustrated from lithographs of specimens in the Godman-Salvin Collection. Fig. 2 shows that, in *Dismorphia*, the transparency is attained, unlike the *Ituna*, by a reduction in size of the scales; while, unlike the *Ithomiinæ*, the normal shape and outline are preserved, almost unchanged.

It is a little remarkable that in this large and dominant group no member of the *Heliconinæ* has yet been shown to find a place.

The moths which join the group are shown in Pl. **44**. fig. 3. I believe that all the convergent species of *Anthomyza* and *Castnia* are represented in the figure; these are, at any rate, all that are to be found in the collection of Mr. Herbert Druce and the Hope Collection. There are, however, other species of *Hyelosia* which I was unable to obtain at the time the photographs made use of in preparing these Plates were taken.

Microscopic examination proves that the moths become transparent in two ways, which differ entirely from each other, and from any of the methods already described in the butterflies. A representation of the scales of the transparent part of the Castnias is shown in Pl. **44**. fig. 6. The scales are not reduced in size, but they have lost their pigment and are transparent; they are furthermore set up on edge so that the light freely passes between them. The scales further from the opaque border of the transparent patches are much more upright than those at the margin which have been selected for figuring. The arrangement in *Hyelosia* is shown in fig. 5, and it is seen to be closely similar to that of *Castnia*, save that the scales are much reduced in number. The lithograph of the scales of *Anthomyza* (fig. 4) proves that the scales are normal in size and arrangement. They lie flat on the wing-membrane with the usual overlap, but are so transparent that the light freely passes through them. Although transparent, they retain a more or less faint yellow or greenish-yellow tinge, but this is also to be noticed in the transparent part of the wings of *Methona*, *Dismorphia*, &c.

The comparison of these details is almost a demonstration of the operation of natural selection. We cannot conceive of natural selection acting other than along some such lines as those which have here been shown to exist; for it is impossible to believe that very different species with very different natures would present anything but very different variations for its action. On the other hand, we cannot conceive of any theory, not dependent upon the principle of selection, which could produce such extraordinary superficial resemblances among numbers of species by methods which are entirely unlike in all their details.

13. *The supposed direct Effect of Local Forces implies the Hereditary Transmission of Acquired Characters.*

Finally, the hypothesis which is more commonly than any other substituted for natural selection, has the further disadvantage that it implies the unproved improbable hypothesis of the hereditary transmission of acquired characters.

A discussion of this latter hypothesis cannot be attempted here. It will be sufficient to observe that after years of search no particle of evidence in its favour, which can stand the test of examination, has been forthcoming.

14. General Conclusions: *Natural Selection as the Cause of Mimetic Resemblance and Common Warning Colours.*

I think it is not too much to claim that, even if the theories which have been proposed as substitutes for Natural Selection, have not been destroyed in single Sections of this memoir,—and I confidently believe that they have been thus destroyed over and over again,—their most convinced supporter will admit that they must yield to the accumulated pressure of all the arguments here brought forward.

The resemblances of mimicry and common warning colours have certain salient features in common, certain peculiarities which are apt to manifest themselves repeatedly; they also bear certain general relationships to other resemblances in organic nature. In this paper I have attempted to set down all the general statements which can be made as to the phenomena under discussion. These general statements represent an

enormous number of observed facts in all parts of the world. I believe that the generalizations will be admitted to be sound and to be well warranted by the facts. Under any theory which is not based upon selection, the whole of the facts on which the generalizations rest become mere coincidences and receive no explanation of any kind. Under natural selection this vast body of facts becomes at once intelligible. Here the accumulated facts of the most diverse kind, which receive an intelligible explanation by the theory in question, yield a firm support to the theory. There are many theories which are held upon indirect evidence of precisely the same nature. We believe in evolution, not because we see it taking place, but because of the immense number of observed facts which it renders intelligible.

In the case of natural selection in relation to mimicry and common warning colours it is to be confidently hoped that direct evidence may yet be added; indeed, a considerable amount is even now forthcoming. Prof. Lloyd Morgan's recent work upon the activities and instincts of young birds of many species ('Habit and Instinct,' London, 1896) proves that their education is actually of the kind which is presupposed in the theories of H. W. Bates and Fritz Müller. He shows that they have no instinctive knowledge of things which are good for food, but examine and test everything. On the other hand, they have very retentive memories, and retain a firm impression of the appearance of objects which have given them an unpleasant experience. Furthermore, there was evidence that they are influenced in their behaviour towards other objects resembling the one which has proved objectionable to them. As to the aggressive Hymenoptera, the evidence of their special methods of defence is obvious to everyone. With regard to specially protected groups of butterflies there is a large amount of evidence from observation and experiment, but more is to be desired. As this paper is going through the press I have received the last of Mr. Frank Finn's interesting and important set of papers on this question (Journal, Asiatic Society of Bengal, lxiv. pt. ii. 1895, p. 344; lxv. pt. ii. 1896, p. 42; lxvi. pt. ii. 1897, p. 528; lxvii. pt. ii. 1897, p. 614). After a long series of experiments begun and conducted with a perfectly open mind, upon Indian insect-eating vertebrates, Mr. Finn concludes in favour of the theories based upon natural selection in the following words:—

"I conclude from these experiments:—

"1. That there is a general appetite for butterflies among insectivorous birds, even though they are rarely seen when wild to attack them.

"2. That many, probably most species, dislike, if not intensely, at any rate in comparison with other butterflies, the 'warningly-coloured' *Danainæ*, *Acræa violæ*, *Delias eucharis*, and *Papilio aristolochiæ*, of these the last being the most distasteful, and the *Danainæ* the least so.

"3. That the mimics of these are at any rate relatively palatable, and that the mimicry is commonly effectual under natural conditions.

"4. That each bird has to separately acquire its experience, and well remembers what it has learned.

"That therefore on the whole, the theory of Wallace and Bates is supported by the facts detailed in this and my former papers, so far as they deal with Birds (and with the one Mammal used). Professor Poulton's suggestion that animals may be forced by hunger to eat unpalatable forms is also more than confirmed, as the unpalatable forms were commonly eaten without the stimulus of actual hunger—generally, also, I may add, without signs of dislike."

Mr. Finn concludes with some very valuable suggestions as to the conduct of future experiments.

The chief objection that has been raised against the theories of Bates and Fritz Müller, and which was often insisted on in the discussion at the Entomological Society, is the want of evidence that birds are in any important degree the enemies of butterflies. Many excellent observers have rarely seen butterflies attacked by birds. On the other hand, the Müllerian theory only presupposes that the young birds test the palatability of a few members of each convergent group in their locality and henceforward avoid all the members, so that the recent tendency to explain so many of these resemblances on Müllerian rather than on Batesian lines is in harmony with the conclusion that the members of such groups are not greatly attacked.

As regards butterflies which do not exhibit these resemblances, I may point out that it is impossible to exhaust the details of the struggle for existence even as regards a single species, in the intervals of the time devoted to collecting. Such an investigation would demand the whole time of a first-rate

observer, and, so far as I am aware, the inquiry has never been approached in so thorough a manner. Even if collectors would pay attention to the worst specimens instead of the best, some evidence of the nature and amount of attack would be forthcoming. During the visit of the British Association to Canada last year (1897) I made a point of capturing butterflies which had evidently been pecked by birds. In this way, although I did not witness a single attack, I obtained the proof that butterflies are not nearly so immune as has been asserted. On another occasion I hope to deal with this evidence in detail. Similar observations have been made by Fritz Müller.

The review of the whole subject during the past 36 years increases our confidence in the theories of Bates and Fritz Müller, while it disposes of all alternative hypotheses. Even more than this,—it will, I believe, be claimed by all who take a broad view over the whole field of evidence, that the explanation of these deeply interesting facts, which form so fascinating and important a department of natural history in the tropics, is one of the most notable triumphs ever won by the great theory of natural selection.

EXPLANATION OF THE PLATES.

Plate 40.

Certain aspects of Mimetic Resemblance in Lepidoptera.

Fig. 1. Natural size. This figure represents the appearance of the young larvæ of *Stauropus fagi* in the first stage, upon a twig of birch. The drawing was made from living specimens in the Hope Department at Oxford by P. J. Bayzand. The ant-like appearance is produced by the immensely elongated second and third pairs of thoracic legs, which are kept in a state of active movement upon the slightest disturbance. The caudal shield with its two processes resembles the head and antennæ of an ant. This figure should be studied in connexion with figures 1 to 7 in the text (Section 11), in which the resemblance to ants is shown to be brought about in many very different ways, thus supporting an interpretation based on the theory of natural selection.

Fig. 2. Natural size. A group of the young larvæ of *Endromis versicolor* upon a twig of birch. Drawn from life in the Hope Department by P. J. Bayzand. The larvæ are represented in the attitude they assume when disturbed, the anterior part of the body being thrown back and the orange-coloured thoracic legs exposed to view. In this position they strongly suggest the appearance of a group of young larvæ of

Tenthredinidæ, in which the *posterior* part of the body is raised on disturbance, while the orange ventral glands are everted and rendered conspicuous. The larvæ of *Endromis* afford a good example of mimetic resemblance almost entirely brought about by appropriate instincts (the gregarious instinct, the movements and attitudes assumed on disturbance). Thus the results are due to internal changes (in the nervous system) with only a minimum of superficial modification.

Fig. 3. Natural size. A group of larger larvæ of *Endromis versicolor*, also drawn upon birch by P. J. Bayzand. The figure shows that as the larvæ increase in size their instincts undergo appropriate changes leading them to form much smaller groups like the smaller groups of the more advanced larvæ of *Tenthredinidæ*. The attitude represented is that which follows disturbance.

Figs. 4–9 were drawn from specimens in the Hope Department, and are intended to show the retention of ancestral features upon parts which are normally concealed and the restriction of mimetic modification of colour and pattern to the parts which can be seen. They incidentally show examples of the more complete development of mimetic resemblance in the female sex.

Fig. 4. About $\frac{3}{5}$ natural size. The male of *Dismorphia praxinoe*, showing the manner in which the long-and-narrow-winged appearance of an Ithomiine is brought about in this broad-hind-winged butterfly. A comparison of the right and left sides of the figure clearly indicates the manner in which this appearance is produced by the excessive amount of overlap which occurs in the natural position of the wings (left side). Hence the greater part of the surface of the upper side of the hind wing and the under side of the fore wing is hidden in a natural position, and upon these concealed parts a large patch of the old Pierine white appearance is retained, seen, in the case of the hind wing, on the right side of the figure.

Fig. 5. About $\frac{3}{5}$ natural size. The male of *Dismorphia praxinoe*, showing the under side of the wings in the natural position (left side), and with the wings separated on the right side so as to expose that part of the under surface of the fore wing which is normally concealed. Here, too, a large white patch is to be seen.

Fig. 6. About $\frac{3}{5}$ natural size. The female of *Dismorphia praxinoe*, figured in the same manner as the male in fig. 4, and showing that the wings are really long and narrow with only the amount of overlap which is usual in butterflies. No white is to be seen upon the narrow band of the hind wing, which is concealed in the normal position.

Fig. 7. About $\frac{3}{5}$ natural size. The female of *Dismorphia praxinoe*, figured to show the under side of the wings similarly to that of the male in fig. 5. Here, too, it is seen that no white patch like that of the male is retained.

Fig. 8. About $\frac{3}{5}$ natural size. The male of *Dismorphia orise* represented in the same position as that of the male of *D. praxinoe* in fig. 4. Here, too, in this transparent, black-barred species, immensely modified by mimetic resemblance, the white patch is still retained (in the male), as

seen on the right side of the figure. The female of the species is shown in Group 1 on Plate **42** and two forms of it in fig. 1 on Plate **44.** The female of *D. orise* lacks, as do all the females of the genus, the chalky patches which are present in the males of many of the species.

Fig. 9. About $\frac{3}{5}$ natural size. The male of *Dismorphia orise* represented in the same position as that of the male of *D. praxinoe* in fig. 5, so as to show the under side of the wings. The white patch is distinctly seen on the normally concealed part of the fore wing (right side).

Plate **41.**

The diverse methods by which Mimetic Resemblance is attained, often in closely related species. I have been kindly permitted to make use of specimens in the Natural History Museum for obtaining figures 1, 2, 5 A, 5 B, and 5 C. The remaining figures represent specimens in the Hope Department.

Fig. 1. Natural size. A South-American Hemipterous insect belonging to the genus *Myocoris*, probably *M. braconiformis.* The usual appearance of a Hemipteron has been profoundly modified so as to produce a superficial resemblance to the Aculeate Hymenopteron shown in the next figure.

Fig. 2. Natural size. A South-American species of *Braconidæ*, probably belonging to the genus *Iphiaulax*, closely resembled by the bug shown in fig. 1. A large assemblage of tropical American insects probably converges round this type of appearance. Already many species of *Braconidæ* and of Hemiptera, together with two species of moths (*Syntomidæ*), can be recognized. So far, all the members of the assemblage belong to distasteful or specially defended groups, and probably supply an example of Common Warning Colours.

Figs. 3, 4, 5, 6, & 7 show the different methods by which the resemblance to stinging insects (Aculeate Hymenoptera) has been brought about in nearly related Longicorn beetles.

Fig. 3. Natural size. A Mediterranean species of *Clytinæ*, *Plagionotus scalaris*; one of many species of the group in which the resemblance to a wasp is produced by the black and yellow bands on the closed elytra, as well as by the slender yellow legs and active movements, &c. In this case the functional wings are concealed, and there is nothing to suggest the wings of the model. In spite of this shortcoming the living species of this group are very wasp-like. The resemblance is carried to a still higher level by very different means in allied tribes of Longicorns.

Fig. 4. Natural size. A species of *Callichrominæ* from the Oriental Region, viz. *Nothopeus hemipterus.* In this beetle the general resemblance to a dark-coloured slender wasp is carried much further than that of *Plagionotus* (fig. 3) to a black and yellow wasp such as the species of the genus *Vespa.* Furthermore the likeness is heightened by the size and conspicuousness of the hind wings of the beetle, which are

freely exposed at rest as well as in flight. This is brought about by a reduction of the elytra to small oval scales. Hence the resemblance which is so largely due to the colouring of these parts in *Plagionotus* is here in an allied form due to the appearance of parts which are concealed, except during flight, in the former. It is also to be noted that the exposed under wings have the dark tint, which is so common in the species of stinging Hymenoptera, and that such exposure of the functional wings is very unusual in Coleoptera and is almost, if not entirely, confined to the species in which their display is made part of a mimetic resemblance.

Fig. 5. Natural size. An Australian species of *Esthesinæ*, *Esthesis ferrugineus*. In this beetle the elytra are reduced to squarish scales and the under wings freely exposed at rest. The bold and characteristic colouring is found in many Australian insects of which three other examples are figured here.

Fig. 5 A. Natural size. An Australian fly, a species of *Dasypogon* (*Asilidæ*), with the same type of colour and pattern as that of the last and the two succeeding figures. This Dipterous insect resembles the wasp represented in fig. 5 B with especial closeness.

Fig. 5 B. Natural size. An Australian wasp, *Abispa australis* (*Eumenidæ*), which is in all probability the central type of this characteristic Australian group.

Fig. 5 C. Natural size. Another Australian wasp, *Eumenes Latreillei* (*Eumenidæ*), which falls into this group. Other species of Australian wasps are also included, and probably additional insects of other Orders from the same region will be found to possess a similar type of colouring.

Fig. 6. Natural size. A Brazilian species of *Rhinotraginæ*, *Isthmiade braconoides*, in which the very slender form strongly suggests the appearance of a Hymenopterous insect. The colouring and pattern of the wings is very rare in beetles, and is in all probability mimetic of some stinging insect from the same part of the world. The elytra are here reduced to linear vestiges somewhat broadened at their bases; they leave the under wings freely exposed.

Fig. 7. Natural size. A species of *Hephæstion* sp. (*Necydalinæ*) from Chili. The appearance is extremely wasp-like, and is brought about by a reduction of the elytra very similar to that indicated in the last figure. The under wings are dark like those of so many wasps, and the whole appearance most suggestive of a stinging insect and unlike that of a beetle.

Thus in this Plate five species of nearly related Longicorn beetles are represented. The appearance of a wasp is chiefly suggested by the colouring of the fully developed elytra of one species (fig. 3), by the reduction of the elytra and form and colour of the parts thus displayed, in all the rest (figs. 4, 5, 6, & 7). Furthermore the elytra are reduced to oval remnants in one (fig. 4), squarish in another (fig. 5), and linear (with broader bases) in the remaining two (figs. 6 & 7). Stout-bodied black and yellow wasps, such as those of the genus *Vespa* (or the *Abispa* shown in fig. 5 B), are resembled by two (figs. 3 & 5),

while the remaining species (figs. 4, 6, & 7) are mimetic of slender Aculeata with opaque, iridescent, or even particoloured wings.

Hence in this group of allied species of beetles there is great diversity in the methods by which the mimetic resemblance is attained and in the form of the model which is imitated. One thing is common to the whole, viz. the production of a strong superficial likeness to a stinging insect. Such community of end through diversity of means strongly supports an interpretation based on the theory of natural selection.

Plate **42**.

The resemblances between the members of a large and characteristic group of transparent and black-barred South-American Lepidoptera.

Fig. 1. About ⅓ natural size. The group as described by Bates in 1862 (Trans. Linn. Soc. xxiii. pp. 495–566). The names of the species are engraved on the Plate. The species belong to very different divisions, families, and sub-families of Lepidoptera. Thus the *Ithomiinæ* are represented by two species in different genera, the *Danainæ* by two species, the *Pierinæ* by one, while the moths belong to the very different families of the *Castniidæ* and *Pericopidæ*, the latter including *Anthomyza*. Bates also described a group of smaller Ithomiine species, *Dircenna epidero*, *D. dero*, and *D. rhoeo*, as well as another smaller moth (*Hyelosia tiresia*) belonging to the *Pericopidæ*. Of these he made a second group, but they are in reality continuous with that shown in fig. 1, having a very similar arrangement of black bars and border on their transparent wings. The group has in all probability converged around the two common and widespread Ithomiine species of the genera *Methona* and *Thyridia*. All members of the group, including these latter, are to be looked upon as primitively opaque-winged. If selection has been at work in the alteration of the scales so as to render them transparent, we should expect that this common end would have been reached by very different methods in the case of species belonging to such widely separated divisions.

Fig. 2. About ¼ natural size. By the kindness of Messrs. Godman and Salvin I have been enabled to figure, from their great collection, all the species of butterflies which are now known to fall into the two groups described by Bates 37 years ago. The *Danainæ* and *Pierinæ* remain unchanged, but the *Ithomiinæ* have been immensely enlarged, containing 20 species in seven genera. Many of these are extremely rare, and so complete a set could not have been got together from any other collection. I also owe to their kindness the loan of butterflies shown in fig. 1 and of some in Plates **43** and **44**.

Many species of *Castniidæ* and of *Pericopidæ* have now been added to the group. Those which are here shown, as well as in fig. 1, and those in Plate **44** were in part obtained from the Hope Collection and in part from the very fine collection of Mr. Herbert Druce, who kindly lent them for the purpose of this memoir. The set is probably complete, or nearly so, except in the genus *Hyelosia*.

PLATE **43**.

The divergent methods by which the transparency—an important element in the resemblance between the members of the group shown on Plate **42**—has been attained in *Ithomiinæ* and *Danainæ*.

Fig. 1. About $\frac{2}{3}$ natural size. The two central Ithomiine species round which the group has in all probability converged. The extraordinarily close resemblance between these butterflies belonging to entirely different genera is a very fine example of common warning colours. The next two figures will show that so close a resemblance is quite superficial; for there is a very wide difference between the shapes of the scales on the transparent areas of the two species.

Fig. 2. × about 15. In this and all the other figures of scales on Plates **43** and **44**, a portion of the transparent patch at the apex of the left fore wing has been figured, including a small part of the opaque margin, so as to show the manner in which the transition is effected. The scales of butterflies and moths overlap from the base of the wing towards its apex, and therefore in the arrangement here adopted the uppermost part of each figure lies in the direction of the apex of the wing. On this Plate a portion of the opaque border on the outer side of the transparent patch, viz. towards the apex, is represented, and is therefore uppermost in each of the three figures. In Plate **44** a portion of the border towards the base has been drawn, and therefore occupies the lowest part of each of the four figures.

The magnification was as nearly as possible equal in all the seven figures representing the scales. All the specimens which were thus drawn belong to the Hope Department. Fig. 2 represents the scales of *Methona confusa*, and it is seen in the upper part of the circle that the opaque surface of the wing is covered with broad forked scales regularly alternating with long and narrow ones. On the transparent part the latter are reduced to extremely fine hairs, the former to minute bifid structures.

Fig. 3. × about 15. The scales of *Thyridia psidii*. The scales of the border in this species are seen to differ somewhat in form from those of *Methona*, while the difference on the transparent part of the wing is very marked, the narrow scales being far broader and the bifid ones of a different shape. The method by which transparency is attained is however the same although the details differ. A method similar in all essential respects was found in all the Ithomiine species shown on Plate **42**. fig. 2. In certain species, however, the process was carried further: thus in *Dircenna* the broader scales were reduced to **Y**-shaped hairs, as well as the others to simple hairs.

Fig. 4. About $\frac{1}{2}$ natural size. The two species of the Danaine genus *Ituna*, *I. ilione* and *I. phenarete*, which enter the group. The *Ithomiinæ* were formerly classed with the *Danainæ*, but the important differences between them are now generally recognized as justifying their separation into two distinct sub-families.

Fig. 5. × about 15. The method by which transparency is attained in the Danaine genus *Ituna* is seen to be entirely different from that followed

in the *Ithomiinæ* (figs. 2 & 3). The scales on the opaque border of the transparent area are almost uniform in appearance, forming the sharpest contrast with those of the *Ithomiinæ*. In the transparent part the individual scales are but little changed in appearance or size, but they are immensely reduced in number, so that the light freely passes between them. The scales which remain merely cause the appearance of a grey dusting over the transparent surface. *Ituna ilione* was drawn for this figure, the other species, *I. phenarete*, only differing in this respect by its even more complete transparency in consequence of a still greater suppression of the scales.

Thus the course of development leading to superficial resemblance has been entirely different in the species of these two sub-families—the *Ithomiinæ* and *Danainæ*.

Plate 44.

Further divergent methods by which the transparency necessary for the likeness has been attained in other members of the group shown on Plate 42, viz. in the *Pierinæ*, and among moths in the *Pericopidæ* and *Castniidæ*.

Fig. 1. About $\frac{1}{2}$ natural size. On the right side is seen the single Pierine species which enters into this group, viz. *Dismorphia orise*. The two upper figures are male and female of the type form found in many parts of tropical South America. Opposite them on the left is a male and female of the type form of *Methona confusa*. The specimen represented in the lowest position on each side is a form which occurs in Ecuador, in which the transparency is increased at the expense of the black bars and border. It is very interesting that this form of *Methona* should thus have been followed by the Pierine butterfly in the same area. The former has recently been distinguished as *Methona psamathe* (Godm. & Salv.).

Fig. 2. ×about 15. The scales on the transparent part of the left apical patch on the fore wing of *Dismorphia orise*, the opaque border being represented at the lower part of the circle. In this case a third method has been adopted. In *Ithomiinæ* the widely different scales were reduced in size and simplified in shape: in *Danainæ* the uniform scales were reduced in numbers rather than in size: while here in the *Pierinæ* they have been reduced in size rather than in numbers, but remain almost unchanged in shape. The amount of reduction in size in this species is better seen by comparison with other parts of the opaque surface upon which the scales are far larger than those of the border which are shown in this figure.

Fig. 3. About $\frac{1}{4}$ natural size. A set of day-flying tropical South-American moths which fall into this group. The two left-hand rows are five species of the genus *Anthomyza*. The upper pair are *A. brotes* (Druce), male left, female right; the next *A. Buckleyi* (Druce), male left, female right; the next *A. Swainsoni* (Druce), both female; the last pair being *A. praxilla* (Druce) on the left, and *A. tiresia* (Cr.) on the right. The two lowest moths of the figure are *Hyelosia tiresia* (Cr.).

These and the species of *Anthomyza* belong to the *Pericopidæ* (*Hypsidæ*). The row of moths on the right hand are widely separated from the others, being the species of *Castniidæ* which belong to the group. The uppermost moth is *Castnia linus* (Cr.), the next *C. dodona* (Druce), the next *C. heliconioides* (Herr.-Sch.), and the lowest *C. micha* (Druce).

Fig. 4. ×about 15. The method by which transparency has been gained in the genus *Anthomyza*. Although *A. Buckleyi* has been drawn for this figure, the method is identical in all the species. The scales lie flat on the wing with an entirely normal arrangement and overlap. Their size and shape are but little altered, but the scales themselves become quite transparent (compare the border scales seen in the lower part of the circle). There is generally a little yellowish or faintly greenish-yellow pigment retained, giving a tint which closely resembles that of *Methona* and other members of the group, none of which are entirely colourless. This method contrasts in a most interesting manner with all the others made use of in attaining transparency as an element in superficial resemblance.

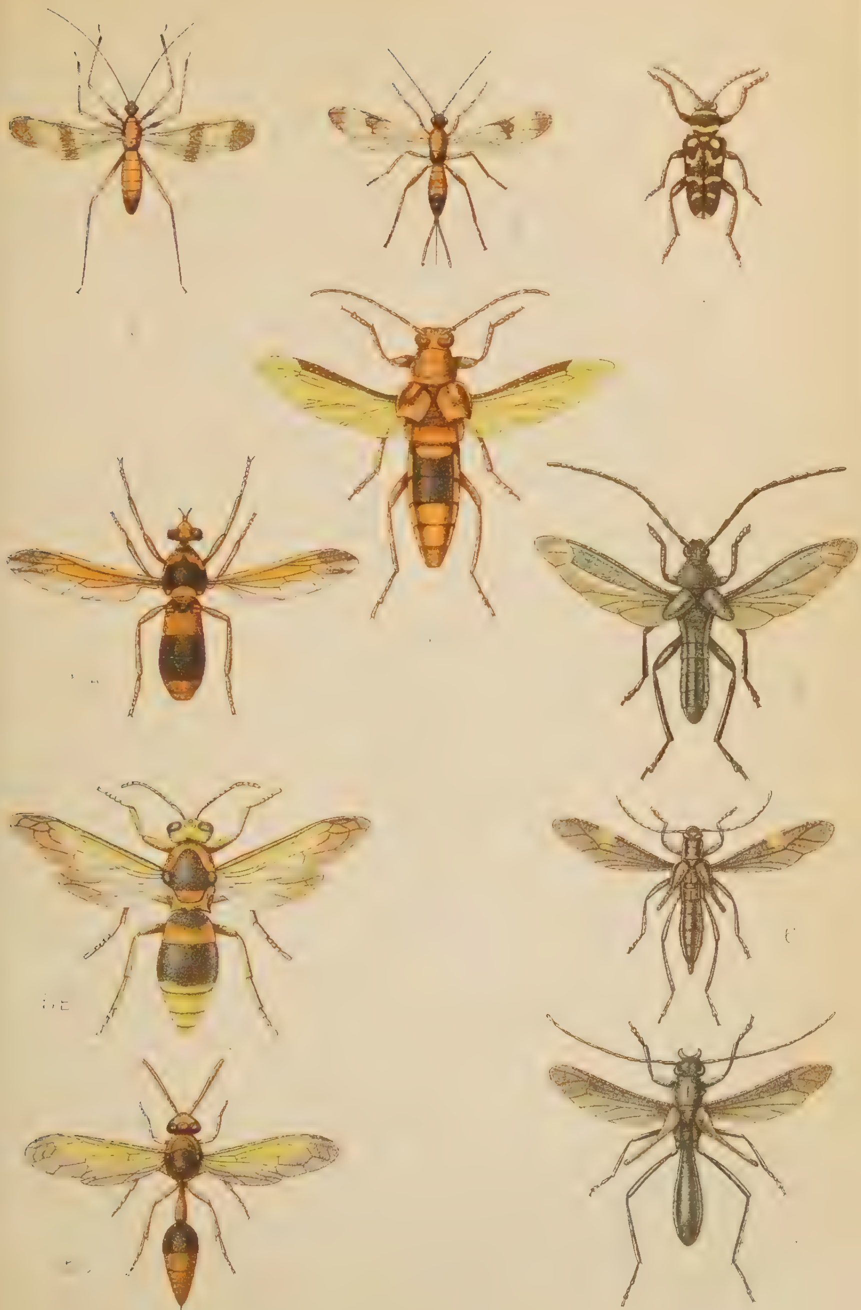
Fig. 5. ×about15. The scales on the transparent part of the wing of *Hyelosia tiresia*, part of the border being shown on the lower part of the figure. The scales are greatly reduced in number, they become transparent and are set in a far more upright position on the wing-membrane. In these ways they interfere but little with the passage of light. The wide contrast with *Anthomyza*, belonging to the same family, is of high interest.

Fig. 6. ×about 15. The method adopted by the species of *Castnia* has much resemblance to that of *Hyelosia*, although the forms are so distantly related. All the species examined have the same method, the scales of *C. linus* being actually drawn for the figure. The scales are not reduced in size and but little, if at all, in number, The shape is somewhat simplified, and the pigment is lost. At the same time the scales are set much more steeply on the wing-membrane, and the light freely passes between their rows. This is seen to be the case in fig. 6, but further from the border of the transparent patch they become practically upright. Even where the slope becomes less the light still passes through (although less perfectly), because of the transparency of the scales.

Hence in this large group of superficially similar South-American Lepidoptera figured and studied in some of its minute details in Plates **42, 43,** and **44,** the transparency which is essential to mutual resemblance has been produced by widely different methods:—the same end, viz., the production of a close superficial likeness, has been reached from very divergent paths. Such a result, while harmonizing with an explanation based on the principle of selection, and especially on the theory of natural selection, is quite inexplicable on any other hypothesis which has as yet been suggested.

WESTWOOD BEQUEST EDWIN WILSON, CAMBRIDGE

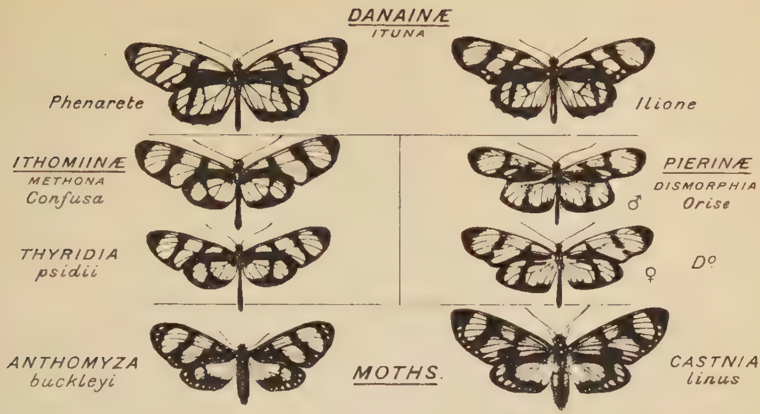
Mimetic Resemblances in Lepidoptera.



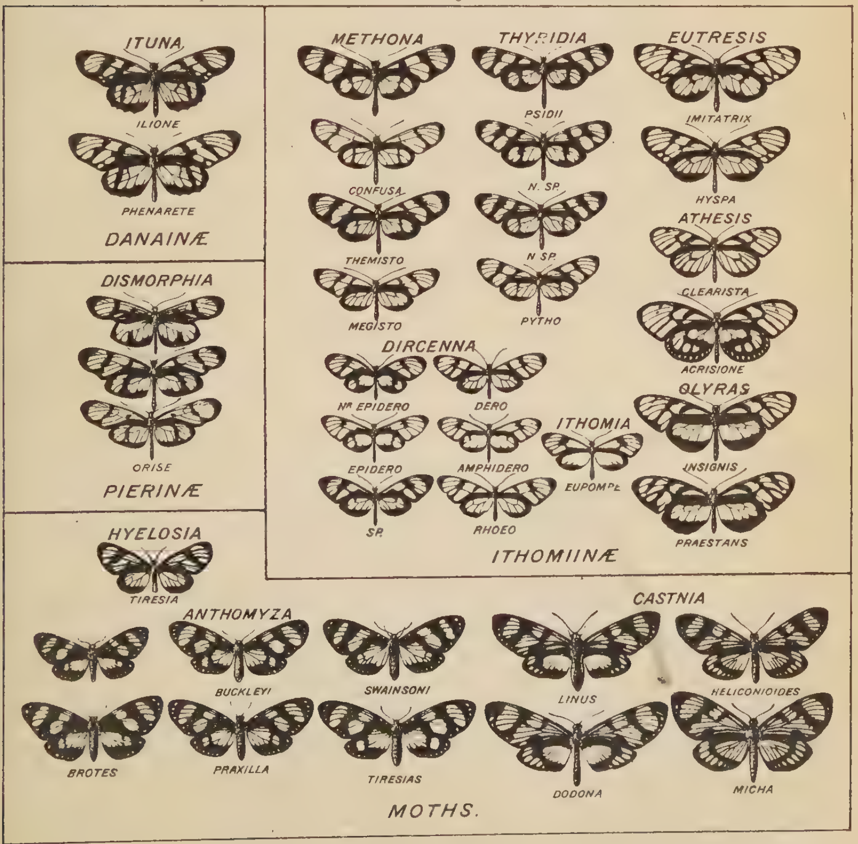
WESTWOOD, BEQUEST

EDWIN WILSON, CAMBRIDGE

Mimetic Resemblances in Insects other than Lepidoptera



1. Group as described by H W Bates in 1861.



2. Group as known in 1897.

Edwin Wilson, Cambridge.

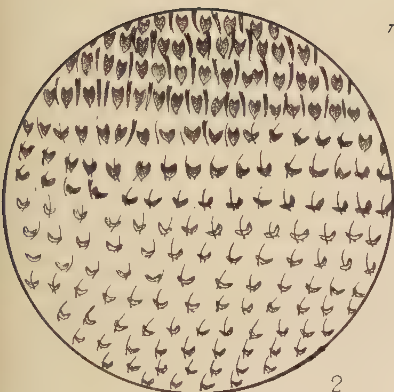
RESEMBLANCES IN TROPICAL AMERICAN LEPIDOPTERA.

ITHOMIINÆ

METHONA confusa

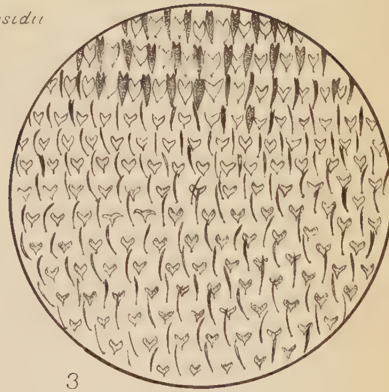
THYRIDIA psidii

1



2

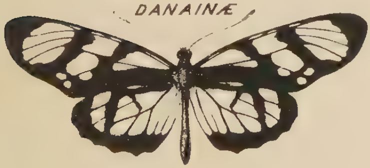
METHONA



3

THYRIDIA

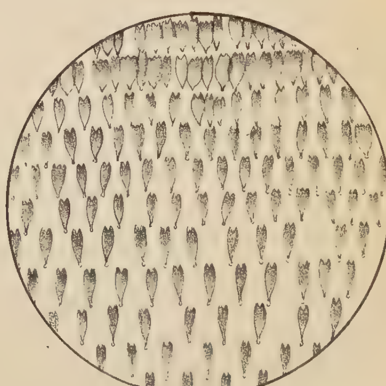
DANAINÆ



ITUNA ilione

ITUNA phenarete

4

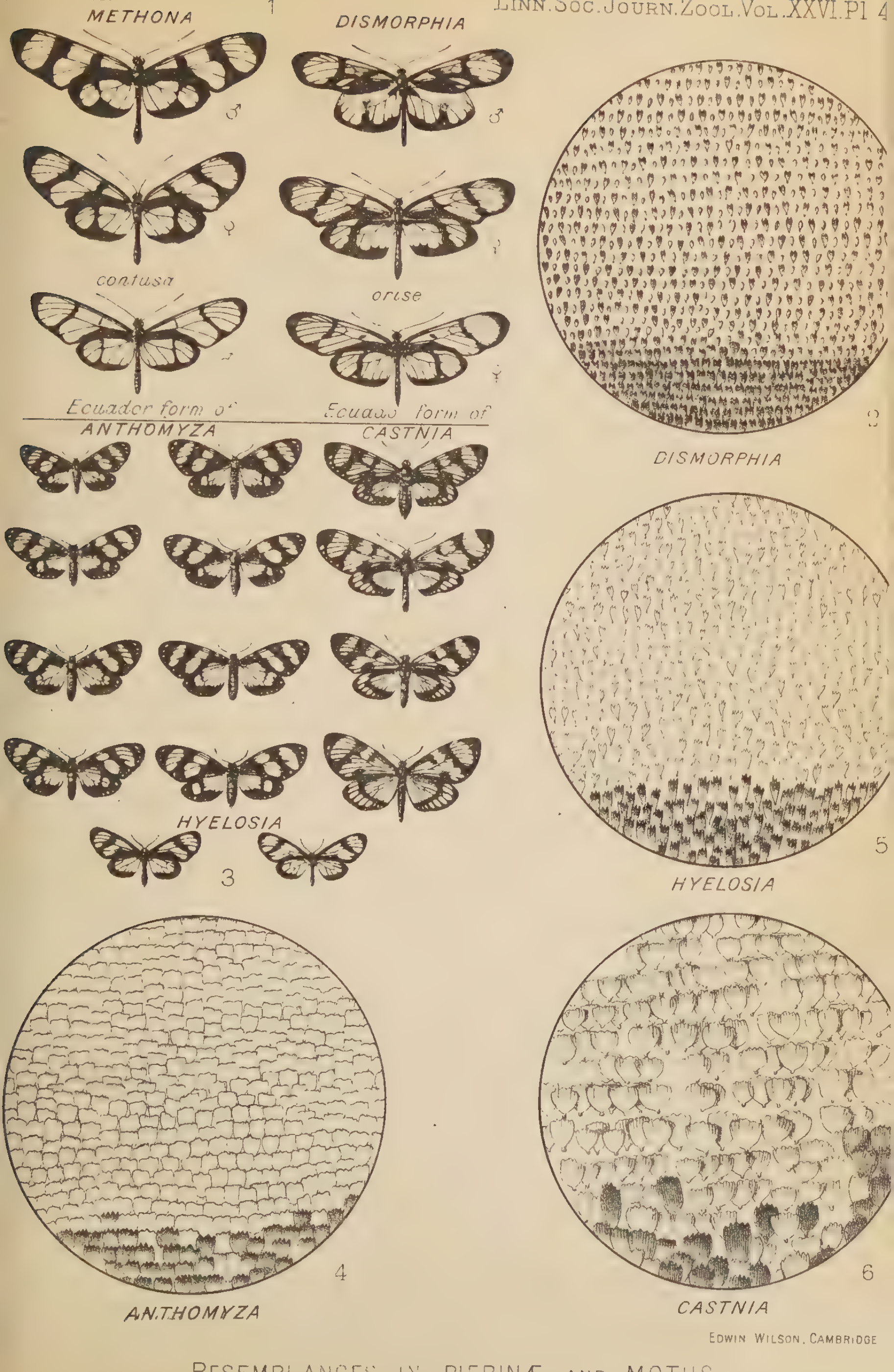


5

ITUNA

Edwin Wilson, Cambridge

Resemblances in Ithomiinæ and Danainæ.



EDWIN WILSON, CAMBRIDGE

RESEMBLANCES IN PIERINÆ AND MOTHS.

On some Arctic Spiders collected during the Jackson-Harmsworth Polar Expedition to the Franz-Josef Archipelago. By Rev O. Pickard-Cambridge, M.A., F.R.S. (Communicated by Prof. G. B. Howes, F.R.S., Sec.L.S.)

[Read 3rd March, 1898.]

(Plate 45.)

A small collection of Araneidea was kindly placed in my hands by Mr. Harry Fisher, by whom they were collected at Cape Flora, June and July 1896. Though very few in number they are of much interest; among them I find

Erigone psychrophila, Thor. ♂ & ♀ ad.
Erigone Fisheri, sp. n. ♀s ad., ♂s imm.
Erigone —— ? ♀ imm.: indeterminable.

Erigone psychrophila, *Thor.* (Pl. 45. figs. 1–7.)

Erigone psychrophila, Thor. Œfvers. af Kongl. Vet.-Akad. Förhandl. 1871, p. 689, and Amer. Naturalist, 1878, p. 393; Cambr. Ann. & Mag. N. H., Oct. 1877, (4) vol. xx. p. 278, pl. viii. fig. 4.

This is the finest species of this group that I have yet seen.

In describing it (*l. c. supra*) Dr. Thorell gave no figures, and the only examples I have before seen were so dilapidated and badly preserved that I could do no more (*l. c. supra*) than simply give an idea of the very characteristic spur beneath the fore extremity of the cubital joint of the male palpus. The specimens now received are in much better condition; it seems therefore worth while to give a description of the spider and more elaborate figures, including one of the female as well as others of the male spider.

Adult male length $1\frac{2}{3}$ line; female rather over $1\frac{1}{2}$ line.

Cephalothorax (of the male) deep rich black-brown; short, broad, very slightly longer than broad. Sides of the thorax very rounded, and their margins armed with a close-set row of sharp, prominent, curved, tooth-like spines. The fore extremity of the caput obtuse; the lateral marginal indentations at the junction of the caput and thorax nearly obsolete. Caput elevated and furnished above with a few minute bristle-bearing tubercles. Clypeus prominent, its height being about three-fourths that of the facial space.

Eyes in two about equally and oppositely curved rows of almost equal length and converging at each end; those of the posterior row equidistant from each other, the hind-centrals smallest. The fore-centrals form nearly a square, the anterior side shortest; those of each lateral pair seated on a strong tubercle; fore-centrals also on a strong prominence.

Legs long, moderately strong, orange-yellow; 4, 1, 2, 3 (relative length, however, not easy to determine, being much twisted together), furnished with hairs only, excepting those of the first pair, which have a longitudinal row of 6 strong teeth at the lower part of the femora on the outer side.

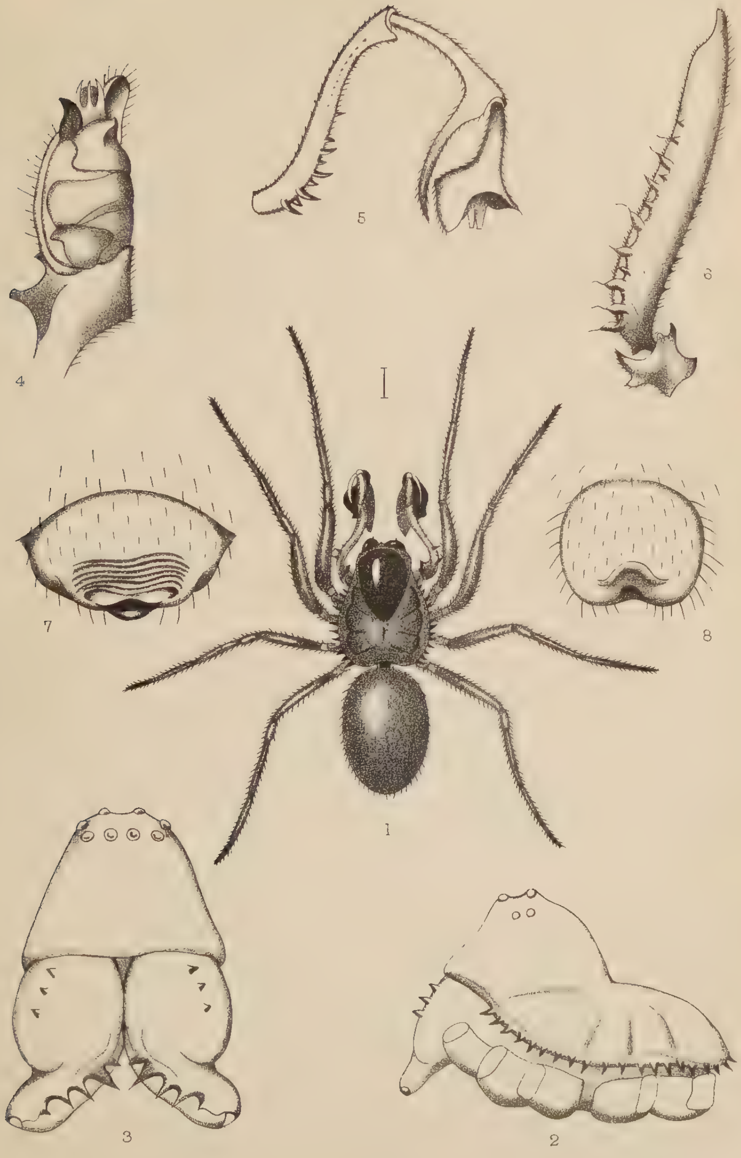
Palpi very long, similar in colour to the legs. Humeral joint long, of a twisted or **S**-shape, armed with, among others, a longitudinal row of denticulations of unequal length towards the outer side: one of these denticulations is obtuse, as if broken off; two others lower down longer and sharp-pointed; there is also a denticular prominence beneath the fore extremity. The cubital joint is long, somewhat clavate, with a long, curved, sharp-pointed apophysis directed forwards and extending beneath the radial joint; this apophysis is as long as the joint itself. Radial joint shorter than the cubital, projecting in a pointed form at the extremity on the upperside, protuberant and projecting also behind, where there is also, near the middle of the protuberant part, a very slight angular prominence (corresponding to the spine in that part of *Erigone dentipalpis*, Wid.); digital joint somewhat oblong-oval, rather large, with a prominent, and rather pointed, lobe near the extremity on the outer side; palpal organs prominent and complex.

Falces strong, rather divergent, roundly prominent at their base in front, where, on the outer margin, are some sharp not very strong denticles; their outer extremities are prolonged, divergent, and abnormally pinched in.

Maxillæ, *labium*, and *sternum* much obscured by particles of adventitious matter, but appeared to be normal, the latter rather drawn out behind and obtusely truncate.

Abdomen black, clothed with short fine hairs.

The adult female resembles the male in colours and general characters. The genital aperture is characteristic. Denticulations round the margin of the cephalothorax and on the falces are visible, but quite rudimentary on the hinder part, or thorax.



F.O.P. Cambridge del. et lith. West, Newman imp.

ARCTIC SPIDERS.

There are also some minute tubercles in a longitudinal row in front of the femora of the first pair of legs, and each tubercle bears a fine hair.

Erigone Fisheri, sp. n. (Pl. 45. fig. 8.)

Adult female, length $1\frac{1}{2}$ line.

This species is nearly allied to *E. psychrophila*, Thor., but the cephalothorax is distinctly longer in proportion to its width and the lateral marginal impression at the caput is stronger. The margins are very finely denticulate, the denticulations bearing short hairs; and the whole spider is of a duller and browner hue. There is also an angular prominence towards the extremity of the maxillæ on the outer side, and a longitudinal row of minute hair-bearing tubercles on the anterior side of the femora of the first pair of legs towards the outer margin. The genital aperture is characteristic and different in form from that of *E. psychrophila*, though bearing much resemblance to it.

Several immature males accompanied the adult females, and I believe them to be of the same species, but, apart from their being adult, it is needless to give any description of them.

EXPLANATION OF PLATE 45.

Fig. 1. *Erigone psychrophila*, Thor., ♂, magnified.
2. ,, ,, Cephalothorax and falces in profile.
3. ,, ,, Cephalothorax and falces from front.
4. ,, ,, Portion of palpus, showing radial and digital joints and palpal organs.
5. ,, ,, Palpus, excepting digital joint, in profile.
6. ,, ,, Femur of first pair of legs in profile.
7. ,, ,, ♀. Genital aperture.
8. *Erigone Fisheri*, Camb., ♀. Genital aperture.

On some Spitzbergen *Collembola*. By the Rt. Hon. Sir JOHN LUBBOCK, Bart., M.P., F.R.S., D.C.L., &c.

[Read 5th May, 1898.]

OWING to the well-known tolerance of cold by the insects belonging to the order Collembola, it is not surprising that several species should occur in Spitzbergen. In Greenland eleven species have been recorded by Meinert *; but, so far as I am aware, only 5 species have been previously recorded from Spitzbergen. The first was originally described by Boheman † as *Podura hyperborea*, but, as I have shown elsewhere ‡, it is a species of *Achorutes*. Five species were added to the Spitzbergen list by Tullberg §: they are *Sminthurus Malmgreni*, Tullb., *Isotoma palustris* (Gmel.), *Achorutes viaticus*, Tullb., *Lipura arctica*, Tullb., and *Lipura grœnlandica*, Tullb. I am now able to add two more species, of which one is new. They were collected, with specimens of two other species, by Mr. Trevor-Battye during Sir Martin Conway's expedition to Spitzbergen in 1896.

Genus I. ISOTOMA, *Bourlet*, 1839.

Species 1. ISOTOMA SPITZBERGENENSIS, n. sp.

Diagnosis.—Pilosa. Antennæ capite non vel paullo longiores, articulus tertius quartusque æquales, secundo longiores. Tibiæ sine setis tenentibus. Unguiculus superior non dentatus. Segmentum tertium abdominale quartum longitudine fere æquans. Furcula usque ad tubum ventralem pertinens. Dentes furculæ manubrio non longiores, recti; mucrones tridenticulati ||. Long. 2–2½ millim.

Habitat. Dickson Bay, Spitzbergen. Collected July 1896.

* FR. MEINERT. "Neuroptera, Pseudoneuroptera, Thysanopoda, Mallophaga, Collembola, Suctoria, Siphunculata Grœnlandica," Vidensk. Meddel. 1896 (1897), pp. 167–173.

† C. H. BOHEMAN. "Spetsbergens Insekt-Fauna," Öfvers. K. Vet.-Akad. Handl. vol. xxii. 1866, p. 577.

‡ LUBBOCK. Monograph of the Collembola and Thysanura, p. 180.

§ T. TULLBERG. "Collembola borealia," Öfvers. K. Vet.-Akad. Handl. vol. xxxiii. 1876, no. 5, p. 42.

|| It has been usual to count the terminal point as a tooth. This seems hardly correct; but I have thought it best to use the usual nomenclature.

Affinities.—A revision of all the Palæarctic Collembola up to 1892 has been published by H. Schött *, who gives diagnoses and a synonymy of most of the species.

This species may be distinguished from other boreal *Isotomæ* by aid of the following synoptical table. I do not, however, wish to commit myself to the opinion that all the species here mentioned are really distinct.

A. Spring not reaching to the ventral tube.
Isotoma fimetaria (Linn.).
„ *minuta*, Tullb.
„ *sexoculata*, Tullb.
„ *quadrioculata*, Tullb.

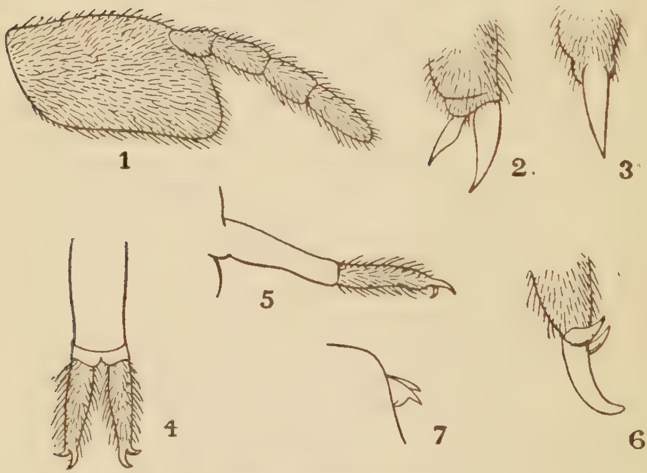
B. Spring reaching to the ventral tube.
a. Antennæ twice, or nearly twice, as long as the head.
Isotoma viridis (Gmel.), Bourlet.
„ *palustris* (Müll.).
„ *aquatilis* (Müll.).
„ *anglica*, Lubbock.
„ *Stuxbergii*, Tullb.
b. Antennæ not, or little, longer than the head.
c. Teeth of the spring obtuse.
Isotoma crassicauda, Tullb.
„ *litoralis*, Schött.
d. Teeth of the spring pointed.
e. Tibia with one or more tenent hairs.
Isotoma Reuteri, Schött.
„ *sensibilis*, Tullb.
„ *clavata*, Schött.
„ *denticulata*, Schäffer.
„ *cinerea*, Nicolet.
f. Tibia without tenent hairs (or tenent hairs not mentioned).
g. Four or more teeth to the mucrones.
Isotoma olivacea, Tullb.
„ *violacea*, Tullb.
„ *hiemalis*, Schött.
„ *grandiceps*, Reuter.

* Harald Schött. "Zur Systematik und Verbreitung der palæarctischer Collembola," K. Svensk. Vet.-Akad. Handl. vol. xxv. no. 11 (1893).

h. Two teeth to the mucrones.
Isotoma bidenticulata, Tullb.
" *grisea*, Lubbock.

i. Three teeth placed one after the other.
Isotoma tigrina (Nicolet).
" *grisescens*, Schäffer.
" *maritima*, Tullb.
" *longidens*, Schäffer.

Figs. 1-7.



Isotoma spitzbergenensis.

1. Side view of head. 2. Side view of foot. 3. Foot seen from above. 4. The spring. 5. Side view of same. 6. Tip of same, more magnified. 7. The catch.

The new species agrees with the last four in the above table in the possession of three teeth in the mucrones; but it differs from them by having two of the teeth at the base, and also by the form of the mucrones. The only two remaining species with which it should be compared are *I. minor*, Schäffer, and *I. notabilis*, Schäffer. *I. minor* * has the dentes of the spring $2\frac{1}{2}$ times as long as the manubrium, and the fourth segment of the antenna is also longer than the third. *I. notabilis* † also has the

* Schäffer. "Die Collembola der Umgegend von Hamburg," Mitt. a. d. Naturh. Mus. Hamb. vol. xiii. 1895 (1896), p. 179.

† Schäffer, *ibid.*

dentes $2\frac{1}{2}$ times as long as the manubrium, and the fourth segment of the antenna longer than the third. The teeth of the mucrones are also differently placed.

Species 2. ISOTOMA QUADRIOCULATA, *Tullb.*, 1871.

Tullberg, "Fört. öfver Svenska Podurider," Öfvers. K. Vet.-Akad. Förh. vol. xxvii. 1871, p. 152; & Tullberg, "Sveriges Podurider," K. Svensk. Vet.-Akad. Handl. vol. x. no. 10, 1872, p. 48, pl. ix. figs. 25–31.

A number of specimens of this minute species were collected at Advent Bay early in August 1896; they were found living in damp moss. The species has been recorded from Greenland, but not previously from Spitzbergen.

Genus II. LIPURA, *Burmeister*, 1838.

Species 1. LIPURA ARCTICA, *Tullb.*, 1876.

Tullberg, "Collembola borealis," Öfvers. K. Vet.-Akad. Förh. vol. xxxiii. 1875, no. 5, p. 39, pl. xi. figs. 47–50.

This species was recorded from Spitzbergen at the time of its first description. It was found by Mr. Trevor-Battye with the *I. spitzbergenensis* on the shore of Dickson Bay.

Species 2. LIPURA GRŒNLANDICA, *Tullb.*, 1876.

Tullberg, *op. cit.* p. 41, pl. xi. figs. 57–58.

This species has also been previously recorded from Spitzbergen, but the precise locality was not stated. The specimens on which the present record is based were collected at Advent Bay on August 12th, 1896, and were found in some wet moss in a swamp.

Notes on some Lories.

By St. George Mivart, F.R.S., F.L.S.

[Read 2nd June, 1898.]

In an interesting and suggestive paper, by Captain F. W. Hutton, F.R.S., lately published in our Journal *, the author pointed out certain facts and made certain inferences with respect to thirteen species of Fruit-Pigeons of the genus *Ptilopus*. Each of these thirteen species he declared to be severally confined (as regards their geographical distribution) to one island, or to a small group of islands, wherein no other species of *Ptilopus* simultaneously existed; and he stated, at some length, his reasons for coming to the conclusion that the specific characters of these species could not have arisen as "recognition marks" nor from any other merely mechanical mode of origin.

Captain Hutton's position may, I think, be strengthened through the consideration of certain facts with respect to the geographical distribution of another group of birds to which, a short time ago, I had occasion to pay particular attention †.

The group in question is that known as the family *Loriidæ*, containing about seventy-five species ranging in size from that of a Sparrow to about that of a Turtle-Dove.

Their plumage is in most cases a mixture of green, purple (or blue), and red, to which yellow is very often added. In some cases the whole body is green, but the plumage may be entirely red. In only two instances is it blue and white.

The distribution of the *Loriidæ* does not extend beyond 10° N. and 45° S. latitude, or west of 115° E. longitude or east of 145° W. longitude. Their extreme northern habitats consist of the Caroline, Washington, and Fanning Islands. Their farthest extension south is to Tasmania; their most western dwelling-place is the island of Sumbawa, while the Marquesas constitute their extreme eastern limit, so far as I have been able to ascertain.

Of a small section of the group—the Black-billed Lories (*Chalcopsittacus*)—one species, almost entirely black (*Ch. ater*), is found in New Guinea; but a closely-allied form (*Ch. Bernsteini*) is, so far as yet known, confined to the island of Mysol, and, one may suppose, has there acquired the tinge of red on its otherwise black forehead. The utility of this trifling character

* Journ. Linn. Soc., Zool. xxvi. p. 330.

† When preparing my work entitled 'A Monograph of the Lories, or Brush-tongued Parrots, composing the Family Loriidæ.' London: R. H. Porter, 1896. Therein 22 types are represented, and 16 species are figured for the first time.

appears to me to be very problematical. It certainly cannot be needed as a "recognition mark," since its otherwise entirely black plumage alone constitutes a complete and ample distinction between it and the three other species of Lory (*Lorius lory*, *Trichoglossus cyanogrammus*, and *Hypocharmosyna placens*), which appear to be the only other species inhabiting Mysol.

Another species (*Ch. insignis*), which, so far, has only been found in the small island of Amberpon, has acquired a bright red tint on the under surface of the wings and tail. This is the more remarkable because up to this time we have no evidence that any other Lory inhabits Amberpon.

Eos reticulata seems only to be found in the Tenimber Islands and Timor Laut, while in the former locality certainly, and in the latter not improbably, no other species has been obtained save *Psitteuteles euteles*, the simple green plumage of which renders the elaborate markings of *Eos reticulata* quite needless as recognition-signs.

Much more striking, however, is the fact that the very exceptional species the Cherry-red Lory (*Eos rubiginosa*) is confined to the small island Puynipet in the Caroline Archipelago. Its remarkable coloration cannot be needed to enable the sexes to recognize each other, for no other species of Lory exists (so far as yet known) in this Archipelago.

Two species (*Vini australis* and *Vini Kuhli*) dwell, each of them, in a habitat which no other Lory shares. The former species dwells in Samoa and the Friendly Islands, while the latter is exclusively an inhabitant of Washington and Fanning Islands.

The Fiji Islands are inhabited by two Lories, *Calliptilus solitarius* and *Hypocharmosyna aureocincta*. The former is the only species of a distinct genus, and is so extremely divergent from the latter in its appearance that its coloration is indeed distinctive far beyond any need there might be for it to serve as means of sexual recognition.

Most remarkable of all, however, is the extremely exceptional distribution of the most exceptionally coloured of all the Lories, namely the Blue Lories—the two species of the genus *Coriphilus*. One of these, *C. taitianus*, was known to and was described by Buffon in 1779 under the name of L'Arimanon *. It is found (as its name implies) in the Society Islands, and is the only Lory there found. The other species, *C. ultramarinus*, is the only one inhabiting the Marquesas Islands, and it is to be found nowhere else.

* Hist. Nat. Ois. vi. p. 175.

The blue coloration of both these species, the white throat of *C. taitianus*, and the white spots on *C. ultramarinus* cannot be "recognition marks." Neither is it to me conceivable that the environment as existing in the Society, Marquesas, and Caroline islands can have educed the blue colour of the two species of *Coriphilus* or the red colour of *Eos rubiginosa*. Would it be reasonable to suppose that these varieties in coloration are correlated with other unknown useful characters? Surely if not only the utility, but even the very existence also, of such hypothetical characters are as yet devoid of even a fragment of evidence, positive belief in such correlation can only be due to a sort of groundless, irrational "faith"!

And here I may be permitted to add a few words in self-defence, since I have recently learned (from private conversation), to my astonishment, that my biological views and arguments have, by some persons, been supposed to be due to a desire on my part to promote views with which physical science has no connexion. Any such purpose I repudiate with all the energy of which I am capable, and I seize this occasion to express my true meaning: When I urge, as I do now, that the instances which Captain Hutton and I have brought forward are fatal to a utilitarian explanation of the origin of all specific characters (or, indeed, of any, because *falsus in uno falsus in omnibus*), I none the less unhesitatingly and unequivocally affirm they are (as a matter of course) due to natural, biological causes. I know *no* causes in nature but *natural* causes, but not all natural causes are mechanical ones.

My objection to this dogmatic assertion, that the latter, as the exclusive causes, are to be, in all cases, accepted on *à priori* grounds (as it has been affirmed they should be accepted *), is due even more to what seems to me to be the intellectual limitations of such a view than to its inadequacy.

After nearly forty years' meditation and examination of the subject, I remain convinced that the cause of specific characters still remains an unsolved enigma. I hope and believe that its solution will nevertheless one day be achieved, but I do not consider it will be so achieved until the higher psychological problems of Biology have become much more widely understood, and the light thus gained has been reflected on questions of ordinary physiology.

* A. R. Wallace, Journ. Linn. Soc., Zool. xxv. p. 481.

On the Food of *Uropoda*.

By Surg.-Capt. H. A. Cummins, M.D., F.L.S.

[Read 2nd June, 1898.]

When examining diseased bulbs of the Easter lily (*Lilium longiflorum*, var. *Harrisii*), which is largely grown in Bermuda, I found them infested by several species of mite.

One of these, *Uropoda ovalis*, Koch, was present in large numbers, and multiplied very freely when kept under favourable conditions in captivity.

This circumstance allowed me a good opportunity of observing what constituted the food of these creatures, which I believe has not hitherto been proved with certainty.

As to my method of investigation and apparatus, I found that rectangular or round glass boxes 2 or 3 inches in diameter, provided with covers as used in bacteriological work, were best suited to the requirements of the case. In the bottom of each box was placed a small piece of moistened filter-paper, and on the filter-paper a lily-scale or small portion of potato. Finally, the lid was sealed after the mites had been introduced.

The supply of air in the box was sufficient to last for several days, but as it was my custom to examine each box daily, there was no danger to be apprehended from suffocation, as the lid was removed.

My attention was drawn to the way in which the mites obtained their food. As they walked too and fro on the lily-scale or potato, the mandibles were rapidly protruded and withdrawn. This was particularly the case at spots on the potato where colonies of bacteria were growing. If, for instance, a mite were removed from a box where it had been living on a lily-scale, and were placed in another which contained potato slimy with bacterial colonies, it fed at first with avidity, but apparently soon became filled to repletion, as the protrusion of the mandibles ceased.

The following is an extract from my notes, and relates to a box which I frequently used for experiments :—

September	16th, 1897.	Introduced about eight *Uropoda* on a lily-scale into the box.
,,	19th.	A few young mites appeared.
,,	26th.	Fresh young.
October	1st.	Great increase in number.
,,	4th.	Further increase.
,,	8th.	Quite innumerable.
,,	11th.	Ditto.
,,	13th.	Ditto.
,,	25th.	Introduced a piece of potato.
November	2nd.	Mites swarming on potato.

In bright daylight the mites usually sought the under surface of the potato, a few walking on the upper surface, but in the evening time they left their hiding-places and wandered over the interior of the box and on the potato.

In this box the slimy colonies of bacteria or wild yeast were absent, and the conditions were well adapted to the experiments, which I carried out in the following manner :—

I scraped some of the slimy masses from a piece of potato which had been specially kept for the purpose. These were placed under a microscope, and when I had satisfied myself that they were composed of micro-organisms, I placed them on the potato in the box, before mentioned, containing mites.

In about half a minute one or two mites would discover the bacterial matter, but soon numbers would collect, scrambling with each other for the food. At this time the mandibles could be seen, with the aid of the microscope, working with great rapidity. In five or ten minutes nothing would be left of the substance I had introduced. The *Uropoda* appear to have the faculty of detecting the presence of food matter situated some distance from them, for soon after its introduction they swarmed almost direct to it from all sides. They certainly did not discover the food by chance.

I tried this experiment several times, and always with the same result.

Amongst the organisms which the *Uropoda* consumed were the following :—

Many species of bacilli, which I could not identify with certainty, but I believe that I detected the ordinary potato

bacillus and the earth bacillus. Wild yeast-cells were rapidly devoured, as was also the case with micrococci. There is little doubt but that they eat the gonidia of fungi, because species of *Penicillium* and *Mucor* never appeared in boxes containing mites in large numbers; otherwise they were commonly present.

I employed about ten boxes for cultivating the *Uropoda*. The mites multiplied freely and appeared very healthy. There was no difficulty in isolating them from other species, as the transference from the lily bulbs to potato was a very simple matter.

The bacteria and other organisms which grew on the potato were sufficient for food, although slimy colonies were not formed if the mites were present in large numbers.

The plain surface of the potato allowed me to place food in such a way that there was no doubt as to its constitution, and that it was actually consumed by the *Uropoda*.

The mites delayed decomposition of the potato, but they were not capable of preventing its final disintegration, because they could not gain access to bacteria which had penetrated deeper than the superficial layers of cells.

On one occasion I saw many *Uropoda* engaged in feeding on the dead body of one of their own species. It is possible that they may have been devouring bacteria which were causing its decomposition.

I am greatly indebted to Mr. A. D. Michael, F.R.M.S., for his assistance. He very kindly named my specimens, which were sent to him from Bermuda where my investigations were conducted.

On *Pantopoda* collected by Mr. W. S. Bruce in the neighbourhood of Franz-Josef Land, 1896–97.

By GEORGE H. CARPENTER, B.Sc. Lond. (of the Science and Art Museum, Dublin). (Communicated by WM. EAGLE CLARKE, F.L.S.)

[Read 16th June, 1898.]

(PLATE 46.)

THE only Pycnogons recorded from the immediate vicinity of Franz-Josef Land are the few species enumerated in the papers of Heller (1) and Miers (2). The material collected by Mr. Bruce is therefore of considerable value in extending our knowledge of the range of these interesting marine animals. As will be seen by the list which follows, eleven species are represented, one of which is believed to be new to science. The remainder will be found excellently described (with full synonymy) and illustrated in Sars's beautiful monograph (4) of the Northern Pycnogonida, which now renders the work of identifying these creatures comparatively easy. In the following list the generic and specific nomenclature of Sars has been followed (except in one instance). It seems to me, however, that the number of families into which he has divided the group will need to be reduced. And while in the present state of our knowledge it is advisable to consider the Pantopoda as a class distinct both from the Crustacea and Arachnida, it seems undesirable to break up the class into three orders as Sars has suggested. These orders—Euchelata, Cryptochelata, and Achelata—are founded on the degree of development of the mandibles. But when the general form and organization of the body remains constant, the presence or absence of a particular pair of appendages cannot be held to warrant ordinal separation. One could not make a distinct order of the moths which have lost their sucking-tube, or of the flies in which the mandibles are not developed. And the Pantopoda form such a well-defined and homogeneous group, that it is better to regard them as a class containing only a single order.

I understand that the material upon which this communication is based will ultimately be deposited in the Museum of Science and Art, Edinburgh.

Family PALLENIDÆ.

PSEUDOPALLENE SPINIPES (*Fab.*).

E. 10. 77° 55′ N. lat., 53° E. long.; 180 fms. July 1897. 1 immature female.

E. 31. Off Cape Mary Harmsworth; 53–93 fms. 1 August, 1897. 1 immature male.

These specimens are both about 3 mm. in length and 20 mm. in expanse of legs; according to Sars (4) adults are $4\frac{1}{2}$ mm. long and 39 mm. in expanse. The female specimen (E. 10) has only five segments in the false leg. In the male (E. 31) the full number of segments (ten) are present, but these limbs are barely as long as the body. In the general form of the body, the legs and their armature, both specimens agree closely with Sars's description and figures.

The discovery of this pycnogon near Franz-Josef Land considerably extends our knowledge of its geographical and bathymetric range. According to Sars it is a scarce shallow-water species (20 fms.) on the coast of Norway, and it has been found also on the coasts of Greenland, Northern Russia, and in the Kara Sea.

Family NYMPHONIDÆ.

NYMPHON BREVITARSE, *Kröyer*.

E. 1. Off Flora Cottage, 1 mile; 15 fms. 10 Sept. 1896. 1 male.

E. 8. $\frac{2}{3}$ mile S.W. of Elmwood; 20 fms. 20 June, 1897. 1 male; 1 immature specimen.

These pycnogons agree closely with Sars's descriptions and figures of this species, which seems to be scarce, though of wide distribution, having been found off the coast of Greenland and in the Strait of Matotschkin Sharr. It appears to be a shallow-water form. I am quite inclined to agree with Sars that it is worthy of specific distinction from *N. grossipes*, if only on account of the different denticulation on the spines of the false legs. It is probable that the pycnogon from Franz-Josef Land, recorded by Miers (2) as *N. gracile*, is referable to this form, as the species which Sars identifies as the true *N. gracile* of Leach is apparently unknown in the Arctic regions.

NYMPHON PILIFERUM, sp. nov. (Pl. **46**. figs. 1, 3–6, 8, 10–13.)

E. 7. $\frac{2}{3}$ mile S.W. of Elmwood; 19 fms. 19 June, 1897. 1 male (egg-bearing).

E. 3. 1 mile off Flora Cottage; 15 fms. 10 Sept. 1897. 1 immature male.

Body elongate, with the lateral processes (which bear prominent setæ at the tip) long and well separated. Head-segment as long as the two following segments taken together; neck slender and elongated, frontal part much broadened (fig. 1). Eye-eminence moderate, obtusely conical, with very large lenses (fig. 3). Proboscis rather shorter than head-segment. Mandibles with elongate slender scape enlarged distally; hand about twice as long as broad, fingers two-thirds as long as hand; scape and hand beset with numerous long hairs (figs. 4, 5). Palp elongate; second and third segments equal in length, fifth rather longer than fourth, cylindrical, beset with numerous long hairs (fig. 6). False legs in male half as long again as body, terminal part longer than the fifth segment; last three segments of equal length, seventh a little longer; sixth, fifth, and thickened distal end of fourth with numerous hairs (figs. 8, 10); denticulate spines with large, blunt, basal processes, and 7–12 (usually 8 or 9) sinuate serrations on each side (fig. 11). Walking-legs (beset with numerous hairs and setæ) with second coxal segment twice and a half times as long as first; second tibial segment a third as long again as first (fig. 1); tarsal segment slightly longer than propodal, which is slender, almost straight, bears five small basal and seven long central spines, a powerful claw and two auxiliary claws less than half as long as main claw (fig. 13).

Male. Length 5·5 mm., expanse 42 mm.

This pycnogon by the density of its hairy covering resembles the species of *Chætonymphon.* It is evidently most nearly related to *N. brevipes* and *N. rubrum*, Hodge, which it resembles in the shape of the eye-eminence and the serration of the spines on the false legs. But the slender palps and the proportions of the segments of the walking-legs, especially the tarsus and propodus, recall *N. grossipes*, var. *mixtum*, Kr.

NYMPHON PILIFERUM, var. ABBREVIATUM, nov. (Pl. **46**. figs. 2, 7, 9.)

E. 31. Off Cape Mary Harmsworth; 53–93 fms. 1 August, 1897. 2 males (egg-bearing). Length 4 mm., expanse 40 mm.

These specimens seem to me undoubtedly cospecific with the form just described, agreeing in the form of the eye-eminence, the proportions of the false legs and walking-legs, the form and serration of the denticulate spines, and the armature of the feet. They differ markedly in the shortened form of the neck, proboscis, scape of mandible, and palp (fig. 2). The terminal segments of the false leg (fig. 9) are shorter, and stouter proportionally than in the type (fig. 8), and each segment bears a smaller number of denticulate spines. In the general form of the body and proportion of the neck and proboscis, this variety recalls *N. glaciale*, Lilljeborg, but it is readily differentiated from that species by the much more elongate legs and the serrations of the denticulate spines, which in *N. glaciale* resemble closely those of *N. grossipes*.

It will be noticed that this variety is from a greater depth than the type form.

NYMPHON GROSSIPES (*Fab.*).

E. 2. Off Flora Cottage, 1 mile; 15 fms. 10 Sept. 1896. 1 male; 1 immature male.

E. 4. Off Bear Bay; about 10 fms. 25 Sept. 1896. 1 immature female.

E. 5. $\frac{2}{3}$ mile S.W. of Elmwood; 19 fms. 19 June, 1897. 1 male; 1 female.

E. 7. $\frac{2}{3}$ mile S.W. of Elmwood; 19 fms. 19 June, 1897. 1 male.

E. 11. $\frac{2}{3}$ mile S.W. of Elmwood; 18 fms. 26 June, 1897. 2 females.

E. 20. Lat. 77° 55′ N., long. 53° 16′ E.; 130 fms. 13 July, 1897. 1 male.

E. 27. Cape Flora; 8 fms.; 23 & 24 July, 1897. 1 female.

E. 28. Cape Flora off West Bay; 8 fms. 23 July, 1897. 1 male.

E. 30. do. do. do. 1 male

NYMPHON GROSSIPES, var. MIXTUM, *Kröyer*.

E. 29. Cape Flora off West Bay; 8 fms. 23 & 24 July, 1897. 2 females; 1 immature specimen.

E. 31. Off Cape Mary Harmsworth; 53–93 fms. 1 Aug., 1897. 5 males, 1 female.

In spite of the weighty opinion of Sars, I do not think that

these two forms can be regarded as more than varieties of a widespread, dominant, and plastic species. In separating them I have been guided chiefly by the length of the neck and the structure of the feet. In most of the specimens classed above as *grossipes*, the eye-eminence is more pointed than in Sars's figure of that form, while in one (E. 27) the propodus is almost straight as in *mixtum*. In the examples which I have referred to *mixtum*, the neck is elongate, the eye-eminence, as a rule, very acuminate (though in some examples it is not more pointed than in typical *grossipes*), and the propodi straight. Yet the proportion between the terminal joints of the palps is rather that which Sars gives as characteristic of *grossipes*, while the propodus is longer proportionally as compared with the tarsus than in his figure of *mixtum*. In size the egg-bearing males (E. 31), which I refer to *mixtum*, are intermediate between Sars's dimensions for that form and for *grossipes*. The variation in these specimens, taken in conjunction with the fact that both forms seem to occur together, tends to support Wilson's view that *mixtum* cannot be specifically distinguished from *grossipes*.

N. grossipes has an immense range, having been found in all Arctic seas, and as far south as Long Island Sound on the Atlantic coast of North America, while it has been dredged from depths varying between 12 and 750 fathoms.

Nymphon Sluiteri, *Hoek*.

E. 19. Lat. 77° 55′ N., long. 53° 16′ E.; 130 fms. 13 July, 1897, 8 P.M. 1 male.

This specimen agrees closely with Sars's figures and descriptions, as well as with the dimensions which he gives for adult examples of this species. It is evidently a scarce form, having been as yet only recorded from the Barents and Kara Seas at depths varying from 20 to 190 fathoms. Through the kindness of Prof. D'Arcy W. Thompson, of Dundee, the Dublin Museum possesses a specimen from Davis Straits, which differs from the eastern examples of the species in its less acuminate eye-eminence.

Nymphon longitarse, *Kröyer*.

E. 12. West Bay, surface. 5 July, 1897. 1 male.

This specimen agrees closely with Sars's descriptions and figures. The species seems somewhat scarce, but has a wide

range—from the south coast of Spitzbergen to Greenland and the eastern coast of North America as far south as Massachusetts, as well as along the whole coast of Norway and to the North Sea (Durham), occurring also in the Kara Sea. It appears to live at a comparatively shallow depth (16–115 fms.).

NYMPHON ELEGANS, *Hansen.*

E. 21. Lat. 77° 55′ N., long. 53° 16′ E.; 130 fms. 13 July, 1897, 8 P.M. Adult female.

E. 24. Off glacier between Cape Flora and Cape Gertrude; about 30 fms. 21 July, 1897. 2 adult females.

E. 33. 50 miles N.W. of Cape Mary Harmsworth; 234 fms. 8 Aug., 1897. 1 young specimen.

These specimens differ slightly from Sars's figures in the greater proportional size of the auxiliary claws on the feet, which are about a third as long as the principal claw in the adults, and half as long in the young specimen. In this character, therefore, the specimens show an approach to *N. macrum*, Wilson.

This species is a typically arctic form. It was dredged at several stations by the Norwegian expedition, at stations varying from 63° N. lat. to 80° N. lat. (off north-west coast of Spitzbergen), and at depths from 148 to 743 fathoms. There is a specimen in the Dublin Museum from Cape Aston, Davis Straits (60 fms.). It has also been taken in Baffin's Bay (72° 40′ N., 57° 15′ W.) at a depth of 118 fathoms, and in the Kara Sea at a less depth (40–70 fms.). The nearly allied *N. gracilipes*, Heller (1), described from Franz-Josef Land specimens, is not represented in Mr. Bruce's collection.

CHÆTONYMPHON HIRTIPES (*Bell*).

Nymphon hirtum, Miers (2).

N. hirtum, Heller (1).

E. 25. Off glacier between Cape Flora and Cape Gertrude; about 30 fms. 21 July, 1897. Adult male and female and 3 immature specimens.

E. 23. Cape Gertrude; 30 fms. 21 July, 1897. 1 immature specimen.

E. 32. Off Cape Mary Harmsworth; 53–93 fms. 7 Aug. 1897. 1 young specimen.

In the immature specimens (especially in the youngest form,

E. 32) an approach to the allied *C. spinosissimum*, Norman (*C. spinosum*, G. O. Sars), is to be noted in the greater proportional length of the auxiliary claws and the more slender mandibles.

C. hirtipes is one of the most familiar of Arctic pycnogons; and from the numerous localities at which it has been dredged, it would appear to have a complete circumpolar range. On the North American coast it goes south as far as Massachusetts. Of the depth at which it is found there are records varying from 25 to 300 fathoms.

There can be little doubt that this is the species recorded by Heller and Miers from Franz-Josef Land as *Nymphon hirtum*; the true *C. hirtum* (Kröyer) being a more southern form, inhabiting the British, Norwegian, and Icelandic seas.

Chætonymphon macronyx (*G. O. Sars*).

(Larva, Pl. 46. figs. 14–16.)

E. 13. 77° 55′ N. lat., 55° 25′ E. long.; 115 fms. 8 July, 1897. 2 males.

E. 14. 77° 55′ N. lat., 55° 25′ E. long.; 115 fms. 8 July, 1897. 1 female.

E. 15. 77° 55′ N. lat., 53° 20′ E. long.; 130 fms. 10 July, 1897. 1 immature male.

E. 16. 77° 55′ N. lat., 53° 20′ E. long.; 130 fms. 10 July, 1897. 1 male.

E. 18. 77° 55′ N. lat., 50° 20′ E. long.; 130 fms. (brown mud). 10 July 1897. 1 male.

This beautiful species has a wide range, from the Faroe Channel to the coasts of Spitzbergen (lat. 80° N.) and the Kara Sea; it is recorded by Sars at depths varying from 148 to 870 fathoms. The structure of this pycnogon is exceedingly characteristic, and these specimens agree closely with the figures given by Sars (4) and Hoek (3). One of the males (E. 16) carries egg-masses, while another (E. 13) bears a number of larvæ with two pairs of legs and a rudimentary third pair. From the figure of one of these larvæ (fig. 14) it will be seen that the first pair of legs has already developed its full number of segments. In the second pair the femur is extremely short, while the tibial and tarsal regions of the limb consist only of one joint

each, the tarsus bearing two spines beneath (fig. 15). In the foot of the first pair the propodus bears four spines (fig. 16). It will be noticed that the claw is long and the auxiliary claws small. In the adult *C. macronyx* the claw is proportionally longer and more slender, and the auxiliary claws proportionally smaller, than in the larva, while the spines beneath the propodus are regular, exceedingly numerous, and very slender.

BOREONYMPHON ROBUSTUM (*Bell*).

Nymphon hians, Heller (1).

E. 22. 77° 55′ N. lat., 53° 16′ E. long.; 130 fms. 8 P.M., 13 July, 1897. 1 immature specimen.

E. 17. 77° 55′ N. lat., 53° 20′ E. long.; 130 fms. 10 July, 1897 (brown mud). 1 female.

This well-known, blind, circumpolar species was recorded by Heller (1) from the neighbourhood of Franz-Josef Land. It has been dredged in most of the Arctic seas of both the Old and New Worlds, and as far south as 60° N. lat. in the Faroe Channel. Its known range of depth varies from 120 to 750 fathoms.

Family COLOSSENDEIDÆ.

COLOSSENDEIS PROBOSCIDEA (*Sabine*).

Anomorhynchus Smithii, Miers (2).

E. 26. Cape Gertrude, Northbrook Island; about 30 fms. 22 July, 1897.

This giant among Arctic pycnogons has already been recorded from the coast of Franz-Josef Land by Miers, who described it as a new genus and species. It has a very wide range in the northern seas, having been dredged from Baffin's Bay, the Barents Sea, the coast of Lapland, the Kara Sea and the Siberian Polar Sea, and the Faroe Channel. The comparatively shallow depth at which the present specimen was obtained contrasts strongly with the great depth at which the species appears to live towards the southern limit of its range—412 fathoms off the west coast of Norway (*Sars*), and 540 fathoms in the Faroe Channel (*Hoek*).

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(2) Miers, E. J.—"On a small Collection of Crustacea and Pycnogonida from Franz-Josef Land, collected by B. Leigh Smith, Esq." Ann. Mag. Nat. Hist (5) vii. 1881, pp. 45–51, pl. vii.

(3) Hoek, P. P. C.—"Report on the Pycnogonida." Zoology of the Voyage of H.M.S. 'Challenger,' Part X., 1881.

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(5) Wilson, E. B.—"The Pycnogonida of New England and adjacent Waters." Report of the U.S. Commission of Fish and Fisheries for 1878, pp. 463–506, pls. i.–vii. Washington, 1880.

EXPLANATION OF PLATE 46.

Fig. 1. *Nymphon piliferum*, sp. nov. Male. × 8*.
2. " " var. *abbreviatum*. Neck, proboscis, &c. × 8.
3. " " Eye-eminence. × 30.
4. " " Hand of mandible. × 30.
5. " " Tips of fingers of mandible. × 100.
6. " " Palp. × 24.
7. " " var. *abbreviatum*. Palp. × 24.
8. " " False leg. × 24.
9. " " var. *abbreviatum*. Last four segments of false leg. [× 24.
10. " " Last segment of false leg. × 50.
11. " " Denticulate spine. × 500.
12. " " Tail-segment. × 30.
13. " " Tarsus and propodus. × 24.
14. *Chætonymphon macronyx*, Sars. Larva. × 30.
15. " " Larva; foot of second pair. × 90.
16. " " " " first " × 90.

* The dotted circle to the left of fig. 1 represents the outline of the egg-cluster carried on the "false legs."

G.H.C. del. [illegible] lith.

Hanhart i

[illegible] FROM FRANZ JOSEF LAND.

On the Relations of certain *Stichodactylinæ* to the Madreporaria. By J. E. Duerden, A.R.C.Sc. (Lond.). (Communicated by Prof. G. B. Howes, F.R.S., Sec.L.S.)

[Read 16th June, 1898.]

That a close relationship exists between the Zoantharian polyps with only a soft body—Actiniaria—and the Zoantharian polyps which form a calcareous skeleton—Madreporaria—has long been recognized. The grounds of resemblance are the general similarity in the number, arrangement, and order of development of the tentacles and mesenteries, and the plan of the mesenterial musculature, all features of fundamental importance in Actinozoan morphology.

Up to the present, however, no more than these general relationships have been established, and systematists have separated the anemones from the coral-forming polyps, though, as researches have been extended, with more and more of a note of warning that they may ultimately be shown to constitute but a single group.

Thus Prof. R. Hertwig (1882, p. 20), referring to his definition of the Actiniaria or Malacodermata in the 'Challenger' Report, observes: "I have included the want of a skeleton in the diagnosis, and therefore separated the Actiniæ from the Corals, for practical reasons; the division is not a natural one." And further: "Most corals will doubtless be placed later on with the *Hexactiniæ*; perhaps a natural division into forms having a skeleton and forms without skeleton may not be possible, as even the closer limitation of the *Hexactiniæ* given here does not exclude the possibility of many of their families having more affinity to single families of corals than to other *Hexactiniæ*."

Commenting upon the same subject, nearly ten years later, Prof. McMurrich (1891, p. 155), in his "Phylogeny of the Actinozoa," remarks:—"I believe that one will not err very much in regard to the relationships of the Madreporaria in accepting the statement of R. Hertwig. . . . The observations which have been recorded since the publication of Hertwig's paper only tend to confirm his opinion. The arrangement of the mesenteries, and their order of appearance, demonstrate conclusively that the

majority, if not all, of the Hexacorallia are closely related to the Hexactiniæ."

The knowledge to hand of the morphology of the soft parts in both Actiniaria and Madreporaria has, as yet, been insufficient to enable a closer relation to be demonstrated. To establish such requires an extended acquaintance with the outward form, anatomy, and histology of a large number of representatives of both groups. Such characters are now known for an abundant and rapidly increasing series of Actiniæ, but the corresponding details for the coral polyps are not so large.

While investigating the numerous *Stichodactylinæ* occurring in the West Indian area, certain features were presented by three distinct genera—*Rhodactis*, *Ricordea*, and *Corynactis*; features which distinguished them from practically all other Actiniaria, and which conformed with characteristics known to occur in coral polyps. Instituting a comparison of upwards of the thirty species of anemones met with in Jamaican waters and of as many coral polyps as could be procured, with what is already known from the researches of Koch, Heider, Bourne, Fowler, and others, the result has been a complete demonstration to my mind that no morphological character appears in the Madreporaria which does not also occur in the Actiniaria, and that we possess in the above genera of *Hexactiniæ*, and possibly in others, forms which differ in no respect from the polyps of corals, except, of course, such as concern the production of the calcareous skeleton. While in the present state of our knowledge it cannot be asserted that they belong to actual coral families, the combinations of the details disclosed appear to warrant the assertion that their relationship with the coral polyps is closer than with the anemones.

The present communication is but preliminary and suggestive in character. It is hoped that when further study has been conducted on the form and anatomy of the soft parts of corals, a fuller contribution may be possible.

Systematic.

The genus *Rhodactis* is restricted by Milne-Edwards (1857, p. 293) to an anemone, *R. rhodostoma*, met with in the Red Sea, and distinguished by the possession of simple tentacles around the margin of the disc and mouth, with other branching tentacles occupying most of the area between. Duchassaing

and Michelotti (1860, p. 45) describe a West-Indian form, *Actinotryx Sancti-Thomæ*, which lately has been transferred by McMurrich (1889, p. 42) to the genus founded by Milne-Edwards and Haime. The only important difference is that in the latter the oral tentacles are compound while they are simple in the type, characters which can only be regarded as specific.

McMurrich found the Antillean species to be not uncommon at the Bahamas, and describes in some minuteness its form and structure. It is extremely abundant in Jamaican waters in the region of active coral-growth, forming carpet-like expansions of considerable extent, and I have been able to confirm and supplement somewhat the previous descriptions. *R. rhodostoma* has not been studied anatomically, while the account of *R. bryoides*, collected by Haddon (1893, p. 121) from Torres Straits, though in preparation, has not yet appeared. Nothing is known of *R. musciformis*, Duch. & Mich. (1866, p. 132), since it was first described. The details to follow will therefore have reference mainly to *R. Sancti-Thomæ*.

The genus *Ricordea* was proposed by Duchassaing and Michelotti (1860, p. 41) for another West-Indian anemone, representatives of which "sont simples dans leur jeunesse, c'est à dire qu'ils n'ont alors qu'une seule bouche, et deviennent composés lorsque leur développement est complet. A cette dernière époque, ces animaux ont 5 bouches situées au centre du disque recouvert, partout ailleurs, de tentacules courts, obtus et non entièrement rétractiles." The authors pertinently add, "Le genre *Ricordea* est, aux autres Actinines, ce que les Méandrines sont aux *Caryophyllées*."

R. florida, the only species known, was also obtained by McMurrich (1889, p. 47) at the Bahamas, and described under the name *Heteranthus floridus*; but the original generic term was restored in a later paper (1896, p. 188). It occurs in abundance in Jamaican waters under conditions similar to those of *R. Sancti-Thomæ*, that is on the sea-floor in the region of active coral-growth. The polyps are so numerous and closely associated as to give rise to the appearance of irregular compact patches on the sea-bottom, when viewed through a water-glass.

While the two previous genera are restricted to tropical waters, *Corynactis* is cosmopolitan in its distribution. *C. viridis*, All., is found in European seas; *C. globulifera*, Ehr., in the Red Sea; *C. parvula*, Duch. & Mich., and *C. myrcia* (Duch. & Mich.), in

the Caribbean Sea; and *C. australis*, Hadd. & Duerd., and *C. hoplites*, Hadd. & Shackl., in Australian waters.

Kwietniewski (1896, p. 597) has recently described the anatomy of *C. carnea*, Stud., and that of most of the other species is now known. The genus is distinguished externally by the tentacles being distinctly knobbed, the outer larger than the inner, and arranged in radial rows in different series, more than one tentacle communicating with an endocœlic chamber.

In the following characters the three Actiniarian genera mentioned admit of a comparison with the Madreporaria. In many respects the deep-sea genus *Corallimorphus*, described by Moseley and by R. Hertwig (1882, p. 21), also presents suggestive features.

Disc and Cœnosarc.

In by far the majority of Actiniaria the disc is approximately circular, and one series of tentacles surrounds only one mouth. On the other hand, many coral genera, such as *Mæandrina*, *Manicina*, and *Mycedium*, produce a permanent mæandriform disc, on which are numerous oral apertures surrounded by but one system of tentacles, the whole being the result of intra-calycinal fission. Compound examples of the anemones *Ricordea* and *Rhodactis* are often met with, their outline exactly recalling that of such a familiar West-Indian coral as *Manicina areolata*. The multioral disc, instead of being circular, presents the begin-ings of a mæandriform condition. Where the polyps possess only one mouth they are circular in outline and small, apparently just separated by division from some compound larger example. The multioral state is more usual in *Ricordea* than in *Rhodactis*. Duchassaing and Michelotti (1860, p. 41) first recorded it for *Ricordea florida*, and regarded the occurrence of five mouths as normal in the adult. McMurrich found the peculiarity less developed in Bahaman representatives, while in my experience it is very general in the abundant Jamaican specimens. One example presented as many as seven distinct mouths on an irregularly-shaped disc, and there is probably no definite limit to their number.

Though not so common in *Rhodactis Sancti-Thomæ*, polyps with two or three mouths on one disc, and not displaying any evidence of further division, are often collected. In both species nearly all sizes of polyps are closely associated in the large areas

covered by them on the sea-floor and amongst the coral-rock, and every stage from the single to the many-mouthed condition may be observed. Sometimes one of these latter may be procured in process of complete longitudinal fission, the two parts ultimately separating, each with its own system of tentacles.

In colonial corals such as *Madrepora*, *Oculina*, and *Cladocora*, the individual discs are distinct from one another, but the polyps are connected by a thin cœnosarc formed, at any rate in the two last, of the united edge-zones or Randplatten. The disc in each is practically circular, and a system of tentacles surrounds but one mouth.

Amongst the anemones the colonial condition is practically limited to the Zoantheæ, and all degrees of union are there met with, from the usually isolated polyps of *Isaurus* to their fusion with cœnenchyme for nearly the whole length of the column as in *Palythoa*. Species such as *Metridium marginatum*, which reproduce asexually by longitudinal division, occasionally exhibit two oral apertures at one time, but the condition is never retained for long. Dr. G. H. Parker ('Science,' Feb. 1898) estimated the two-mouthed polyps in this species to be in the proportion of about 1 in 700, while Mr. Van Vleck stated that his experience gave it as 1 in 200 or 300. I have also found the phase to be not uncommon in groups of *M. dianthus* on the west coast of Ireland.

In other examples of Actiniaria where asexual reproduction by whatever means occurs, the polyps become separated entirely one from the other. Although the process has been studied in *Metridium* and other forms, no mention is made of individual polyps remaining connected by a basal cœnosarc. *Corynactis*, however, presents an interesting condition. With regard to the British *C. viridis*, Gosse states that he has "seen some which were evidently connected together by the base, the process of separation being incomplete"; while in the West-Indian *C. myrcia* I have come upon small groups in which two polyps, even at a little distance apart, were still united by a narrow cœnosarc. Taking this in conjunction with other characters yet to be noted in the genus, I regard the phase presented by *Corynactis* as indicative of a colonial condition in which all the polyps produced asexually remain united by a basal cœnosarc, just as in corals like *Madrepora* and *Cladocora*. It is apparently an advantage for skeletonless polyps multiplying thus to separate completely,

while the converse holds for forms producing a support: hence we may perhaps regard the multioral mæandriform examples of *Ricordea* and *Rhodactis* as suggestive of an ancestry in which a skeleton was present, and the last remnants of a cœnosarc in *Corynactis* might also be thus explained.

Tentacles.

The subulate form is that generally assumed by the tentacles in Actiniæ, but it is not unusual to find them rounded or slightly swollen at the apex; rarely, as in the Indo-Pacific genera *Thalassianthus*, *Actinodendron*, and a few others, they may branch or become arborescent. The only species of coral I have come upon with complex tentacles is *Astræa radians* (Pallas). In this the members of the inner cycles are all distinctly bifurcated for about half their length, each half bearing a knob at its free extremity.

Though genera with subulate tentacles occur also amongst the corals, the greater number possess tentacles consisting of a conical stem terminated by a more or less distinct globular head of a different colour. Amongst anemones, *Corynactis* and *Corallimorphus* are apparently the only forms in which the tentacles present such a distinctly conical stem and globular head, exactly recalling those of coral polyps. The stem and knob of the tentacles of *Corynactis*, at any rate, exhibit strongly contrasting colours. Histologically the difference is also maintained, the apex constituting a battery of long narrow nematocysts, while they are absent from the stem.

The tentacles in such diverse genera as *Phellia*, *Discosoma*, and *Ricordea*, may terminate in a knobbed or rounded manner, but the distinction between the stem and head is never so marked as in *Corynactis* and many corals.

The arrangement of the tentacles of *Rhodactis* admits of a close comparison with that of *Corallimorphus*. In each case a single cycle of marginal tentacles occurs, different sizes alternating and probably representing different series not yet separated centripetally; on the disc, intermediate or accessory tentacles communicate with the same mesenterial spaces as the marginals, and are much divided in the first genus, but simple and knobbed in the second.

McMurrich (1889, p. 46) states that the marginal tentacles in *Ricordea* are in a single row, but Jamaican examples are dicyclic, the outer row corresponding with the disc tentacles and the inner and larger alternating. The coloration of the stem and rounded head is different.

With regard to the close external resemblance borne by the tentacles and other parts of *Corynactis* to those of a coral such as *Caryophyllia*, the opinion of Gosse (1860, p. 292) may be here quoted:—"There is much in the appearance of this animal [*C. viridis*] which agrees with *Caryophyllia*: the colours and their distribution, the general translucency of the tissues, the form and crenation of the mouth, and, in particular, the shape, arrangement, and minute structure of the tentacles, are so exactly those of the Coral, that I have often more than half suspected that the former is the immature condition of the latter."

According to Gosse (p. 309), the tentacles in *Caryophyllia* are "set in several rows, diminishing in size from the outer row inward, each consisting of a stem with a globular head"; an arrangement corresponding with that in the stichodactylinous *Corynactis*. In the development of *Caryophyllia cyathus*, G. von Koch (1897, p. 759) found the tentacles in the first two cycles of six to alternate.

With the exception of odd irregularities the tentacles in *Corynactis viridis* and *C. myrcia* are tetramerous. Such an arrangement may occur at times in other anemones, but is apparently never so constant a feature as in this genus. My observations show that the mesenteries in *C. myrcia* are likewise in fours, eight complete pairs representing the first and second cycles, and eight incomplete alternating pairs representing the third. This tetrameral symmetry in an anemone possessing so many coral characteristics suggests the consideration of its relationship with the ancient "Rugosa." Connected with the question should be borne in mind the interesting fact that in the octamerous coral *Caryophyllia rugosa*, Moseley, G. von Koch has shown (1889) that at first six septa of the first order are developed, then six of the second order, and that it is only with the appearance of the third order that the development becomes altered in such a way that we ultimately obtain the octamerous condition of the adult.

Lips, Stomodæum, and Gonidial Grooves.

In most Actiniaria no very sharp line of demarcation between the disc and stomodæal walls is observable; the lips are thickened, and the transition from the external to the internal tissues is gradual. The same may be affirmed of the strong histological alteration which is always presented between the ectoderm of the disc and that of the actual stomodæum. In many Madreporaria, especially in those forms where numerous oral apertures are enclosed within one system of tentacles, the distinction between the coloured disc and the white stomodæum is very clearly and sharply defined by a definite border. Amongst anemones *Ricordea* and *Rhodactis* are the only examples in which, in my experience, such a sharp boundary can be observed; the peristome is elevated, but no rounded lips serve as a means of gradual transition from the exterior to the interior.

Further, the stomodæal wall in all Actinians may be thrown into longitudinal ridges and furrows, more marked in contracted preserved specimens. They are, however, rarely regular or permanent and, with the exception of those due to the attachment of the mesenteries, are not recognizable in the living extended polyps. In the two genera just mentioned the outer œsophageal surface throughout its whole extent displays deep, sharply-defined corrugations, which do not disappear when the mouth is fully extended or the œsophagus partly protruding. In microscopic sections the ectodermal ridges are seen to be supported upon very considerable processes of the mesoglœa, greater than those which occur in other anemones. They bear no definite relation to the number and position of attachment of the mesenteries connected with the wall internally. McMurrich (1889) in his description of the two West-Indian species, also mentions these pronounced folds, and figures (pl. iv. fig. 3) the appearance presented in transverse sections by those of *Rhodactis Sancti-Thomæ*.

The stomodæum of most of the corals I have examined exhibits a similar appearance. When the mouth is opened and the stomodæum partly extruded of such a form as *Manicina*, regular distinct white ridges are displayed all along the length of the latter, the number being about eight on each side, but varying with the size

of the oral aperture. As shown in microscopic sections, they are not to be confused with the position of attachment of the mesenteries.

The presence or absence of œsophageal or gonidial grooves in Actiniarian polyps cannot now be regarded as a character of much phylogenic importance, seeing that so many exceptions and not well-defined cases are recorded in widely different groups. Their association with the directives is also inconstant. In *Actinoporus elegans*, Duch., I have found two pairs of directives and only one œsophageal groove. This is all the more noteworthy, as in this instance the single groove is exceptionally large and clearly defined by considerable histological modification.

Corynactis, *Ricordea*, and *Rhodactis* are devoid of gonidial grooves throughout the length of the stomodæum, and it is significant that apparently no grooves are known to occur in any recent coral polyps, though there is little doubt that the fossulæ in Palæozoic corals are the correlatives of the presence of gonidial grooves and shorter directive mesenteries in these ancient types of coral polyps.

With regard to the stomodæum in *Fungia*, Bourne (1887, p. 17) observes:—"I was unable to trace the existence of gonidial grooves (siphonoglyphes) at its ends, though they no doubt exist. When alive the animal constantly closes the middle portion of its mouth, leaving small apertures at the extreme ends through which currents of water pass in and out." This action is well known in anemones, and I have also observed it in living corals; it does not necessarily indicate that true gonidial grooves are present.

Mesenterial Filaments.

Commenting upon Hertwig's suggestion in the 'Challenger' Report that at some time it may be found not possible to separate Zoantharian families without from those with a skeleton, H. V. Wilson (1890, p. 3) remarks:—"A strong argument against this view of the Madreporaria is, I think, afforded by a study of the mesenterial filaments. Porous and aporous corals alike have simple filaments, but actiniæ have trifid filaments." Since this was written several Actiniæ have been described in which the mesenterial filaments are simple throughout. The

absence of the Flimmerstreifen * is stated by Carlgren (1893) to be characteristic of the genera *Protanthea* and *Gonactinia*, constituting the family Gonactinidæ; Appellöff (1893, p. 12) notes their absence in *Ptychodactis patula*, the Nesseldrüsenstreifen only being present; and McMurrich (1893, p. 139) states that the Flimmerstreifen appear to be lacking in the Protactinian *Oractis Diomedeæ*. Though usually strongly developed in all Zoanthidæ, I have lately found the Flimmerstreifen to be absent in a new West-Indian *Epizoanthus*. As regards the corals, however, the assertion of Wilson still expresses the condition in the group. No example, so far as I know, has yet been described with more than a single lobe to the filament, and this holds for the dozen or so species of Antillean corals which I have already sectionized.

In view of this almost universal presence of trilobed filaments in the middle region of the mesenteries in Actiniaria, and of only the simple form throughout in Madreporaria, it is of some phylogenic significance to find that in no part of the length of the mesentery are lateral lobes observable in the West-Indian species of *Corynactis*, *Ricordea*, and *Rhodactis*.

Sections through the backwardly directed terminal region of the stomodæum of *Corynactis* show no difference whatever from sections through the same region in the coral *Cladocora*. In each the ectoderm of the stomodæum is in unbroken continuity with the deeply-staining filaments at the free edge of the chief mesenteries. In each the filaments are at first cordate in section, and throughout are sharply marked off from the rest of the

* The German terms Drüsenstreif or Nesseldrüsenstreif and Flimmerstreif, and their English equivalents "glandular streak" and "ciliated streak," are not strictly synonymous with the terms middle and lateral lobes, though usually so regarded. The former refer to parts with a definite histological structure, and I hope to show in a subsequent paper that only a limited region of the middle lobe of the trilobed filament can be regarded as the morphological Drüsenstreif or glandular streak, and, similarly, only a portion of the lateral lobes is really the Flimmerstreif or ciliated streak.

The free extremity of the mesenteries in nearly all coral polyps displays a more or less trilobed outline in transverse sections, but the two lateral lobes are here only enlargements of the ordinary mesenterial epithelium, are devoid of a mesoglœal axis, and bear no relationship to the lateral lobes of a typical anemone with the ciliated streak. In many of the latter the mesenteries in the proximal part of the polyp may be similarly trilobed, even though below the region over which the ciliated streak extends.

mesentery. Traced below they soon become rounded and bear exactly similar elements—granular gland-cells, ciliated supporting cells, and large nematocysts. *Rhodactis* and *Ricordea*, in like manner, never display any trace of the Flimmerstreifen. In each case the actual filamental expansion is scarcely broader than the mesenterial epithelium, and passes more or less insensibly into it. On many of the well-developed mesenteries in *Ricordea florida* there is no histological modification whatever suggestive of a filament.

Fowler (1886, p. 8) is inclined to regard the peculiar modification met with in some of the mesenteries of *Madrepora Durvillei* as representing the Flimmerstreifen. It is clear, however, that the structures he refers to are but swollen parts of the mesenterial endoderm. The cells are totally unlike the extremely narrow ciliated cells of the Flimmerstreifen in the Actiniaria, and these latter never contain zooxanthellæ.

Nematocysts.

The assertion is usually made that the coral polyps are characterized by much larger and more complicated stigmatic cells than those of anemones. Thus Hertwig (1882, p. 23), in discussing the probable relationship between the Corallimorphidæ and *Corynactis*, observes :—" Many might also consider as points of affinity the fact that in both genera [*Corallimorphus* and *Corynactis*] the nematocysts attain an extraordinary size, that both genera recall the skeleton-forming Zoantharia, and that the nature of the mesoderm is the same in both."

Nematocysts of more than one kind generally occur in the same species, and though capable of development in almost any region of the polyp, they are more usual in the tentacles, stomodæal ectoderm, and the Drüsenstreif of the mesenterial filaments. Where acontia occur, as in the Sagartidæ, the nematocysts in them are somewhat larger. In coral polyps it is usually the oval form which attains increased dimensions, and the internal thread is but loosely spiral and often striated and minutely spinous proximally. Such are best seen in the lower region of the mesenterial filaments and in the stomodæal ectoderm.

A few anemones bear nematocysts comparable in size with those of coral polyps. In the quotation given above, Hertwig implies this to be the case in *Corallimorphus* and in *Corynactis*.

I have also been able to demonstrate the same for *C. myrcia*, and Haddon and myself (1896, p. 152) for *C. australis*. Kwietniewski (1896) makes no reference to those of *C. carnea*, Stud.

Throughout its internal tissues, *Rhodactis Sancti-Thomæ* bears enormous horn-coloured nematocysts. So remarkable a feature are they in sections that Prof. McMurrich (1889, p. 45) observes that they looked almost like encysted nematode parasites. His measurements gave a length of about 68 μ and a breadth of 27 μ. The wall of the cyst is much thickened and bears spinous projections, and the thread is finely striated. They occur in the greatest numbers in groups in the lower part of the mesenterial filaments and in the endoderm of the so-called disc-tentacles. Those of *Ricordea florida* are a little smaller, but nevertheless constitute a very distinct feature in sections through the lower region of the polyp. It is a curious fact that McMurrich's sections of Bahaman examples of this species contained no nematocysts whatever, not even at the tips of the tentacles. I find at least two kinds to be very abundant in Jamaican specimens—a long narrow variety at the knobbed end of the tentacles, and the large oval form in the internal tissues. Having directed Prof. McMurrich's attention to the disparity, a more special examination proved that the original statement was correct. Two examples I have sectionized since agree with those from the Bahamas in this entire absence of stinging-cells.

Mesoglœa.

The mesoglœa of the Actiniaria usually contains small stellate or rounded cells distributed with approximate uniformity throughout the fibrillar or clear homogeneous ground-substance. Sometimes, as in the Zoantheæ, it may, in addition, enclose cell-islets, or become broken up by irregular canals, ingrowths from the ectoderm or endoderm or from both. In most Sagartidæ and in some other Actiniæ parts of the muscular system may also be embedded within it. The middle layer of the Madreporaria, on the other hand, is generally less developed and clear and homogeneous throughout, an isolated cell occurring but rarely. Thus Bourne (1887, p. 18), who originated the term mesoglœa, states:—"I could find no trace of structure in this layer [mesoglœa] in *Fungia*, though it is possible that the use of proper reagents in the fresh condition might have disclosed a

fibrillar structure." And again (1887 *a*, p. 6) :—" The mesoglœa in *Mussa* is perfectly structureless."

Fowler records similar conditions for most of the corals studied by him. In all the coral polyps I have examined the nature of the mesoglœa is of this simple character; the layer stains slightly with borax-carmine, and an included cell is but rarely observed. Though such a difference between the mesoglœa of Actiniaria and Madreporaria is perhaps of no great morphological significance, being only one of degree in the number of cells included, yet it is a very marked distinction when examining sections of representatives of the two groups.

Of the anemones, *Corynactis* is the only form I have met with in which the mesoglœa is nearly perfectly structureless, exactly recalling that of coral polyps. Unless slightly stained its presence is not easily detected in the clear field of the microscope. Both *C. myrcia* and *C. australis* agree in this respect. The mesoglœa of *Ricordea* and *Rhodactis* contains numerous cells, as in other Actiniaria, though they are not by any means so plentiful in the former as in the latter. From all accounts, the mesoglœa of *Cerianthus* appears to be clear and homogeneous.

MUSCULATURE.

In most anemones the musculature is well developed, and supported upon more or less complicated folds of the mesoglœa, or may ultimately become buried within it. Distally a concentration of the circular endodermal muscle, known as the sphincter muscle, generally occurs in the column-wall, but forms devoid of it are not rare. The musculature of the Madreporaria is by contrast but feebly developed, the mesoglœal foldings rarely attaining a complicated outline. In such a large form as *Fungia*, however, the muscle-layer is stronger, the mesoglœa becoming arborescent for its support. A sphincter muscle in coral polyps was first discovered by Fowler (1888, p. 12) in *Sphenotrochus rubescens*. Compared with that of most anemones, it is of a very weakly diffuse character. Fowler also states that in the same species both the longitudinal and oblique muscles of the mesenteries are exceptionally well developed, the former applied to such arborescent pleatings of mesoglœa as have been described among both Madreporaria and Hexactiniæ. I have lately met with a diffuse endodermal sphincter muscle,

similar to that in *Sphenotrochus*, in two or three West-Indian corals.

McMurrich draws particular attention to the weakness of the musculature in both *Rhodactis* and *Ricordea*, regarding it, and the absence of a sphincter muscle, as of family importance. With respect to that of the mesenteries in *R. Sancti-Thomæ*, he writes: "The mesenteries, like the other regions of the body, have the muscular layers very weakly developed, the longitudinal foldings of the mesoglœa, so characteristic in other species, being almost undeveloped and represented only by very slight rounded elevations." The same remark may be applied to the two species of *Corynactis* that I have examined; the mesoglœa of the mesenteries never discloses more than slight foldings for the support of the musculature (1896, pl. vii. fig. 9).

Studying together sections of the mesenteries of *Corynactis* and *Cladocora*, there is the closest similarity in their appearance, both in the homogeneity of the mesoglœa and in the weakly developed retractor muscles. The diffuse endodermal sphincter of *C. australis* and *C. viridis* (1896, pl. viii. figs. 10 & 11) should also be compared with that given by Fowler of *Sphenotrochus*.

With the exception of its well-known presence in *Cerianthus*, a columnar ectodermal musculature was until lately regarded as a rare feature in Actiniæ, but now many genera and species are known to exhibit such. Hertwig (1888, p. 12) first recorded an ectodermal muscle in *Corynactis* (?) sp. and a very weak layer in *Corallimorphus obtectus*, comparing its presence with that in Hydroid polyps and Scyphostomæ, where the ectodermal system is well developed. McMurrich (1893, p. 143) has since met with it in *Halcurias pilatus* belonging to the primitive Halcampids; Carlgren (1893, p. 23) adopts it as a character for the whole of the Tribe Protantheæ; Appellöf (1893, p. 8) found it in *Ptychodactis patula*; while I have ascertained it to be well developed in two species of *Bunodeopsis* (1897), and in *Corynactis myrcia* and *C. australis*, and to be very weak in *Phymanthus crucifer*.

In all these cases the muscle-layer is associated with an ectodermal nervous system on the column, and with a like muscular and nervous development in the ectoderm of the stomodæum, while the sphincter muscle is absent or but feebly represented. Chalmers Mitchell (1890, p. 555) made out the presence of a thick longitudinal ectodermal muscular layer in the stomodæum of *Phymanthus* (*Thelaceros*) *rhizophoræ*.

An ectodermal musculature has apparently never been described in the Madreporaria, though the figure which Fowler (1888, fig. 9) gives of *Sphenotrochus rubescens* suggests muscle-fibres between the ectoderm and mesoglœa. I have determined its presence in the edge-zones of at least two West-Indian corals.

Mesenteries.

No distinction of any importance between the well-known arrangement of the mesenteries in Hexactinian polyps and that of Madreporarian polyps has yet been advanced. Departures from the hexameral symmetry are, however, numerous in both. Even the same species of anemone may be hexamerous or octamerous. Thus McMurrich (1893) found Bahaman specimens of *Aiptasia annulata* to be octamerous, while several Jamaican examples I have examined are all hexamerous. With regard to the order of development of the pairs of mesenteries, a difference may also be indicated in closely allied species of Actiniæ. Some specimens of *Aiptasia annulata* which I have retain the "*Edwardsia*-stage" in the adult, so far as concerns the perfect mesenteries, the fifth and sixth pairs (the sulco-sulcular and sulculo-sulcar laterals of Haddon) to be developed never reaching the œsophagus. In young examples of *Aiptasia tagetes* also only four pairs of the first cycle reach the œsophagus, but the imperfect mesenteries in this case are the innermost of each of the lateral pairs on each side (the sulco-sulcular and sulculo-sulcar laterals). We have thus evidence that the bilateral and biradial types of Boveri may be assumed in the same genus.

Fowler has shown that directives are absent in the coral *Lophohelia*, and Bourne in *Mussa* and *Euphyllia*, and the absence of one or both pairs of directives is not uncommon amongst anemones.

In a recent paper, "On some Irregularities in the Number of the Directive Mesenteries in the Hexactiniæ," McMurrich (1897) points out that the complete absence of directives is not necessarily a phylogenetic peculiarity, and cites several instances in which such occurs in widely removed species. Similarly, an increase of directives beyond the usual two pairs is occasionally observed. In the paper mentioned, the author refers to seven examples of *Sagartia spongicola*, in six of which this happens.

In a West-Indian species of *Phellia*, with eight pairs of perfect

mesenteries, I find a pair of directives alternating with each pair of ordinary mesenteries, there being thus four pairs of each, the arrangement recalling that which McMurrich found in specimen No. 7 of *S. spongicola*. No gonidial grooves are here distinguishable.

In the same contribution special reference is also made to the cases of *Ricordea florida* and *Rhodactis Sancti-Thomæ*. No directives were found in one specimen of the former, and but a single pair, situated to one side of the long axis of the stomodæum, in another. In the latter species one pair of directives was met with in two specimens, while in a third none were discernible. As to these irregularities, my results agree with those of McMurrich. No directives were distinguishable in two young specimens of *Ricordea*, but in another two pairs were disclosed. In several polyps of *Rhodactis* I was able to definitely ascertain only one pair.

Corynactis myrcia possesses eight pairs of perfect mesenteries, of which two pairs are directives. They represent the first and second cycles, and eight alternating pairs represent a third cycle. In the upper part of the stomodæum, an odd member of the free series may be complete for some distance. This is especially noticeable in the region of the pairs of directives.

Some specimens of *C. australis* possessed only one pair of directives, while another displayed two pairs. The arrangement and number of pairs of perfect and imperfect mesenteries on each side are very irregular. Kwietniewski found two pairs of directives in *C. carnea*.

Summary.

The following is a recapitulation of the characteristics in the possession of which the Actiniarian genera *Corynactis*, *Rhodactis*, and *Ricordea* exhibit decided Madreporarian affinities.

Corynactis.—The occasional retention of a thin connecting cœnosarc in asexual reproduction; tentacles with a conical stem and a globular head; no gonidial grooves; mesenterial filaments simple, the Drüsenstreif only being developed; large oval nematocysts; mesoglœa practically homogeneous; endodermal musculature and sphincter weak, the mesoglœal surface supporting it being only sinuous or slightly folded; tentacles and mesenteries tetramerous.

Rhodactis and Ricordea.—Retention of a multi-oral disc; sharp division between the peristome and stomodæum; stomodæal wall regularly and deeply ridged; no gonidial grooves; mesenterial filaments simple; large nematocysts; weak musculature throughout.

Corallimorphus should also be mentioned as presenting many coral relationships—*e. g.* knobbed tentacles, no gonidial grooves, weak musculature, no sphincter muscle, large nematocysts; indeed all the members of Carlgren's Protantheæ reveal suggestive conditions.

Odd instances of the above characters may be present in other anemones, but, so far as yet known, no other Actiniæ exhibit such a combination of affinities. On the other hand, coral polyps are not alike in the possession of all of them. All that can be claimed is that the *tout ensemble* is more decidedly Madreporarian than Actiniarian. Morphologically both the Actiniaria and Madreporaria present such diverse features amongst themselves that little importance can be attached to any isolated detail in a species, but where so many are associated in the same species or genus the relationship claimed becomes almost irresistible.

It is significant that the suggestion which Gosse (*ante*, p. 641) made, from external characters alone, of the close resemblance of *Corynactis* to the coral *Caryophyllia* should be supported in every important detail by anatomical study.

In the present state of our knowledge of the morphology of the Madreporarian polyp, it cannot be asserted to which actual coral families the three genera are most nearly related. They differ amongst themselves in fundamental respects, and the allies of *Corynactis*, at any rate, must be far removed from those of the other two.

Whether the forms specially studied are to be regarded as representatives of more ancestral anemones from which the skeleton-producing polyps may have taken their origin, or as coral polyps belonging to different families which have for some reason lost the power of secreting a skeleton, must, for the present, also be left an open question.

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Observations on *Membraniporidæ*.

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[Read 30th June, 1898.]

(PLATES 47–49.)

THE genus *Membranipora*, as now understood, contains more species than any other genus of Bryozoa, as may be seen by a reference to Miss Jelly's Catalogue of Marine Bryozoa, where out of 1696 species 156 belong to *Membranipora*. It is, however, not very clear how far either the family or the genus should be limited; for Hincks, in his 'British Marine Polyzoa,' places *Flustra* under Flustridæ, whereas in the 'Polyzoa of the Adriatic,' 1886, he puts *Flustra* under Membraniporidæ, while Busk puts *Electra* in another family.

As to the genus *Membranipora*, large as it now is, it has been much reduced by various new genera being formed out of it. Among others, the following have been proposed:—*Electra*, *Onychocella*, *Steganoporella*, *Micropora*, *Chaperia*, *Farcimia*, *Membraniporella*, *Thalamoporella*, *Amphiblestrum*, *Ramphonotus*, *Pyripora*, *Bathypora*, *Caleschara*, *Foveolaria*, *Rhagasostoma*, *Thairopora*, *Craspedozoum*, *Diploporella*, *Monoporella*, *Biflustra*, *Tremapora*, *Periteichisma*, *Mollia*; of which a few are generally accepted, while others are not, for the attempts to break up this large family have been numerous and many have been unsuccessful.

For a complete study of *Membranipora*, comparisons must not be confined to present limitations, and I had hoped to make my work more complete, but now find it better to leave wider generalizations until dealing with related families, and trust the results now laid before the Society may show where further study is required. Each character has been taken separately and tabulated comparisons have been made of the ovicells, the avicularia, the opercula, rosette-plates, and even of the spines.

MacGillivray places *Farcimia*, *Selenaria*, and *Lunulites* in the family Membraniporidæ; but without expressing any opinion as to where they should be placed, I have thought it better to leave the discussion of these for the present. Groups have been made of species which, based upon similarity of one or more characters, seem to be related, but until a larger number have been anatomically examined and the development studied, we cannot be sure of our grouping. The anatomy of *Membranipora* has

been studied by Nitsche *, Freese †, Vigelius ‡, and Prouho §, but this has been confined to the *Membranipora pilosa* and *membranacea* groups, and it is very desirable that some of the other sections should be thoroughly examined. In the *M. pilosa* the intertentacular organ is known, and the larva occurs as *Cyphonautes*: thus in both particulars corresponding with *Alcyonidium* and some Ctenostomata, but in the other groups we know nothing of the anatomy.

The recent Membraniporidæ are mostly incrusting, but this is not always the case, as may be seen in *M. hians*, Hincks; *M. perfragilis*, H.; *M. tubigera*, B. The first two are sometimes unilaminate, sometimes bilaminate, and in fossils bilaminate forms are fairly abundant. The *M. sigillata* of Pourtales is reticulate. The margins are raised; there is a membrane over the front of the zoœcium, and in this the operculum, which is "incomplete," is situated. In some species the ova are developed without ovicells; in others the ovicell is immersed or prominent. The avicularium only exceptionally has a complete bar.

The most important character is the operculum attached to the membranous cover; and the first impression that they were in this family too similar to furnish useful characters has been entirely modified, and it is seen that in forming groups they must not be neglected, and in fact the examination of this organ shows that one group must be removed on this account to another genus, and perhaps should go to another family.

This group was indicated by Jullien ‖ under the name *Chaperia*; but while he based it upon two lateral plates, which I have shown are for the attachment of the opercular muscles and do not occur in all species, the important character is the form of the operculum, which is separable, and which has at each side an elongate protuberance for the attachment of the muscles (Pl. 47. figs. 9, 10). This group, which was no doubt abundant

* "Beiträge zur Kenntniss der Bryozoen," Zeit. f. wissensch. Zool. vol. xxi.

† "Anat.-hist. Untersuch. von *Membranipora pilosa*," Arch. für Naturgesch. vol. i., 1888.

‡ Die "Bryozoen" gesammelt während der dritt. u. viert. Polarfahrt des Willem Barents.

§ "Contrib. à l'histoire des Bryozoaires," Arch. de Zool. Exp. sér. 2, vol. x. p. 557.

‖ "Remarques sur quelques Espèces de Bry. Cheil.," Bull. Soc. Zool. de France, vol. vi.

in the Tertiary and Cretaceous periods, is represented by *Chaperia acanthina*, Q. & G., *C. annulus*, Manz., *C. capensis*, B., *C. cristata*, B., *C. cervicornis*, B., ? *C. cylindracea*, B.; and although Jullien took a character which only sometimes occurs, it has seemed simplest to retain the name he gave.

Kirkpatrick refers *Chaperia acanthina*, Q. & G., to *Lepralia*; but in *Chaperia* the avicularia have not a complete bar, whereas in all the *Lepraliæ* I have examined the bar is complete; and the muscular attachment of *Lepralia* is not quite similar.

In what I should call typical opercula of *Membranipora*, namely, in the opercula of *M. curvirostris*, H., *M. Flemingii*, Busk, *Onychocella angulosa*, Reuss, there is on the distal edge a well-developed flap (Pl. 47. fig. 7) or bow; on the other hand, in *M. membranacea*, *M. nitens*, Hincks, there is only a thickened border (Pl. 48. fig. 17). The structure of *M. hians*, H., is peculiar (Pl. 48. fig. 16), and somewhat resembles that of *M. Lacroixii* (Pl. 48. fig. 15) and *M. californiensis*, sp. nov.; but with these exceptions is unlike that of any other species, for the operculum has a flap and is continued distally beyond this, "forming a membranous extension which closes in the upper part of the cell."

Turning next to the ovicells, there are three groups, the *Membranipora* (*Electra*) *pilosa*, the *M. membranacea*, and the *M. catenularia* groups, in which no ovicells are known in living forms, whereas they occur in several fossils. *M. pilosa* is placed by Busk, Hincks, and Norman in the genus *Electra*, and the chief character upon which the separation is based is the absence of ovicells. This is no doubt an important character, and the form of the ovicell should always be duly considered; but we must be careful that we are not led too far and attach undue importance to the ovicell until the mode of reproduction has been studied, remembering that sometimes the ovicells may be of specific and sometimes of generic value; whether we are ever justified in going further than this cannot be decided at present. In the genus *Lepralia* there are some species with, and some without, external ovicells. *Lepralia Pallasiana*, Moll, is described as without ovicells, nor in typical species from several localities have I ever found any, but Mr. Hincks describes * one with ovicells. Without having had an opportunity of examining it, I am unable to pronounce any opinion, but perhaps it should be

* Ann. & Mag. Nat. Hist. ser. 5, vol. vi. p. 77, pl. x. fig. 3.

called a variety. However, the *Lepralia Otto-Mulleriana*, Moll, is closely allied to *L. Pallasiana*, and in previous papers I have called it a variety of *L. Pallasiana*, and have described the ovicells; and certainly, whether looked upon as a variety or a species, generic separation cannot be thought of. Cases in other genera could be given, as warning against placing too much reliance upon the presence of an external ovicell. In the Flustridæ four cases of an external ovicell are known, and *Membranipora tenuirostris*, Hincks, and *curvirostris*, Hincks, both have prominent ovicells, whereas in *M. gregaria*, Hell., which is apparently allied, they are immersed.

One group, of which *M. Flemingii*, B., may be taken as a type, has a definite area which is less raised than the rest of the ovicells; and another, with *M. lineata*, L., as the type, has a rib across; but these two forms of ornamentation seem to pass into one another, as may be seen in *M. aurita*, H., where a rib surrounds the area.

Before leaving the ovicells it may be mentioned that the *M. serrata* of MacGillivray has an immersed ovicell entirely similar to those in the group *Flustra dentigera*, *F. denticulata*, and *F. spinuligera*. MacGillivray called attention to its similarity to *F. denticulata*, but since then *F. spinuligera*, H., has been discovered, and the avicularia and the mandibles of this and *M. serrata* are quite similar. Then, further, *M. serrata* has about 10 lateral rosette-plates, and 6 distal, as in the above-mentioned group of *Flustra*. I am not aware of any other *Membranipora* with similar rosette-plates, though both *M. gregaria*, Hell., and *M. sceletos*, B., in the rosette-plates and other characters are much like *Flustra*.

I have elsewhere shown that the division which Dr. Gregory makes in his British 'Palæogene Bryozoa,' and in his 'Jurassic Bryozoa,' of genera with internal and those with external ovicells is frequently unavailable, and do not need to further enter into the discussion.

It has not previously been noticed that the avicularia of *Membranipora* usually have no complete bar (Pl. 47. fig. 2), though there are exceptions, as in *M. crassimarginata*, Hincks, *M. armata*, Haswell, *M. sculpta*, MacG., *M. acuta*, Hincks, *M. aperta*, B. In most genera the avicularium is divided by a strong bar. This should be borne in mind, although it may only be another way of saying that *Membranipora* is not usually strongly calcified.

A number of species have vicarious avicularia, which Busk * defines as avicularia which "represent or replace an ordinary zoœcium," in contrast to adventitious avicularia, which are "either attached to some part or other of a zoœcium or interspersed among the zoœcia."

Although it is useful to speak of vicarious avicularia, it is impossible to draw a hard-and-fast line. In such forms as *M. crassimarginata*, Hincks, *M. perfragilis*, Hincks, the avicularian chamber is the same shape as the ordinary zoœcia, and may well be called a zoœcial avicularium, whereas in *M. pyrula*, H., and *M. permunita*, H., the avicularian chamber is much smaller and of a different shape. From these to the avicularia of *M. tenuirostris*, &c. is only a step, and it would seem best to consider vicarious avicularia those in which the avicularian chamber extends to the basal wall, dividing them into vicarious similis, and vicarious dissimilis. Adventitious avicularia are those which are placed upon the zoœcium, as in *M. spinifera*, Johnst., or in *M. echinata*, d'Orb.

There are vicarious avicularia in the genus *Onychocella*, and also in *M. crassimarginata*, *M. pyrula*, *M. valdemunita*, *M. perfragilis*, *M. longicornis*, *M. papulifera*, *M. marginella*, *M. nobilis*, *M. aperta*, *M. corbula*, *M. dissimilis*, *M. sceletos*, *M. velata*, *M. flustroides*, *M. maderensis*.

The avicularia are articulate in *M. Carteri*, and pediculate in *M. cristata*, *M. cymbæformis*, *M. spinifera*, *M. echinata*, and *M. echinus*. In *M. elliptica* and *M. imbricata* the avicularian opening is very narrow.

The rosette-plates have been examined in a number of species, but of many I have not had suitable material, and where particulars are given from the examination of small fragments, which could not be broken up, it is possible that a mistake may have been made even although reasonable care has been taken.

In some *Membraniporæ* the rosette-plates are simple disks in the zoœcial walls as in *Flustra*; in others, as already mentioned by Levinsen †, there are chambers at the base of the zoœcium into which the protoplasmic threads pass from the neighbouring zoœcia. The pore-chambers (*porekamre*) must be looked upon as equivalents of the rosette-plates as far as their number and

* Zool. 'Chall.' Exped. pt. xxx. p. xviii.

† Danske Dyr (Mosdyr), Zool. Danica, p. 7.

position, while the pores within the chamber must be compared with the communication pores of the rosette-plates. The occurrence of these interzoœcial chambers should always be mentioned, but it does not seem as though any wide generalizations can be based upon the fact of the connection being direct or through a chamber. This indirect method of communication is found in many of the higher Chilostomata, and will subsequently be dealt with. I described and figured these pore-chambers in *Cribrilina cribrosa* *, and on account of these chambers Jullien made this the type of a new genus *Collarina*, although they occur in many Cribrilinæ, *Membraniporella*, and in a large number of Chilostomata.

Smitt also figures the pore-chamber in *M. trifolium*, Wood, and refers to it in this species and in *M. lineata*, L.

In many cases the most convenient method is to boil in caustic potash, well wash, and boil in water to prevent further change taking place; and in this way incrusting forms are frequently separated from the seaweed and shells upon which they grow, and the interior can be examined, besides which the calcareous and purely chitinous parts can be more readily studied.

Levinsen †, as his definition of the group A of the *Membraniporæ*, says "forbindelspladerne" (rosette-plates) do not show through upon the underside of the colony, and do not form curved lines within the border in the front part of the individual zoœcia. These chambers can well be seen in *M. lineata* (Pl. 48. fig. 9), and here there are acute spines within the chambers which he calls "tandformede forlaengelse."

The lateral rosette-plates are found in several creeping forms, and may here be of determinative value, as seen in various genera; among others *Pyripora* and creeping *M. inarmata*.

In the distal wall there may be only *one* rosette-plate, as in *M. corbula*, *pyrula*, *papulifera*, *patellaria*, *tenuirostris*, *acuta*, *argentea*, *crassimarginata*, *falcifera*, *inarmata*, *minax*, *perfragilis*, *radicifera*, *Rosselii*, *solidula*, *valdemunita*, *cristata* var. *bilaminata*, *elliptica*, *pilosa*, *maderensis*, *Lacroixii*, *aurita*, *sejuncta*, *umbonata*, *granulifera*, *angulosa*.

Or *two*, as in *M. membranacea*, *nitens*, *C. acanthina*, *cervicornis*, *capensis*, *M. danica*, *imbellis*, *gregaria*.

* Ann. & Mag. Nat. Hist. ser. 5, vol. iii. p. 36, pl. ix. fig. 4.

† Danske Dyr, p. 53.

Or *three*, as in *M. craticula, pura, sceletos, perfragilis* (?).

Or *four*, as in *M. cylindracea*.

Or *six* or more, as in *M. hians, tubigera, Savartii, catenularia, tehuelcha.*

On the lateral wall there may be *two* rosette-plates, as in *C. cristata* var. *bilaminata, capensis, M. tripunctata, catenularia, nitens, patellaria, radicifera, tenuirostris, solidula, papulifera, valdemunita, angulosa, perfragilis.*

Or *four*, as in *M. pilosa, danica, pura, tehuelcha, maderensis, corbula, pyrula, inarmata, craticula, unicornis, lineata, aurita, Dumerilii, Sophiæ, acuta, patellaria* var. *multijuncta, Flemingii, minax, trifolium, argentea, umbonata, granulifera, imbellis, crassimarginata, Savartii, falcifera.*

Or *six*, as in *M. hians, permunita, flustroides, bidens.*

Or numerous, as in *M. tubigera, serrata, armata, sceletos, punctigera, curvirostris, gregaria, imbricata.*

The combs in *M. nitens*, H., and *M. tehuelcha*, d'Orb., which almost divide the zoœcia into two parts, are most interesting structures, and the question is raised as to whether they must be compared with the denticular plate in such species as *M. hians.*

The *Membranipora serrata* is removed to *Flustra*, and *M. roborata* is also removed from *Membranipora* to *Flabellaris*, for from the shape of the zoœcia and the position of the rosette-plates it is clear that it belongs to the group of *Menipea flabellum*, L., *M. cirrata*, Lamx., &c. (see my "Notes on Bryozoa from Rapallo," Journ. Linn. Soc., Zool. vol. xxvi. p. 2).

The groups proposed are :—

No. 1. Chaperia group.—The operculum is "complete" (corresponding with the aperture), with a low ridge on each side, for the attachment of the powerful muscles. The rosette-plates are mostly large, and about halfway between the front and basal walls. The ovicells have a separate operculum. Confined to the Southern hemisphere.

No. 2. Pyripora group.—Ovicells unknown in recent forms, but known in fossils. No avicularia.

No. 3. M. pilosa group (*Electra*, auct.).—No avicularia or ovicells. Operculum with thickened border. Larva cyphonautes. As far as examined the tentacular organs exist.

No. 4. M. MEMBRANACEA group.—No avicularia, no ovicells, no pore-chambers. Operculum with thickened border. Intertentacular organs known in *M. membranacea.*

No. 5. M. CORBULA group.—Zoœcia with spines over the front; ovicells mostly with a rib; avicularia frequently vicarious; usually pore-chambers.

No. 6. M. ECHINUS group.—Ovicells unknown; avicularia pediculate or articulate.

No. 7. M. LINEATA group.—Ovicells with rib; pore-chambers usually one distal, four lateral ones; spines round the border.

No. 8. M. PATELLARIA group.—Ovicells when present cucullate; mostly without avicularia. The front lamina directed inwards below the proximal end of the oral aperture. The zoœcia joined by more or less tubular connections.

No. 9. M. FLEMINGII group (*Amphiblestrum*, auct.) (*Ramphonotus*, auct.).—Ovicells with more or less arched area on the front; usually lamina over considerable part of the front. Pore-chambers.

No. 10. M. TENUIROSTRIS group.—Vicarious avicularia (*dissimilis*).

No. 11. M. CRASSIMARGINATA group.—Ovicell umbonate, with partial rib; avicularia vicarious.

No. 12. M. CORONATA group.—Small avicularium above the zoœcium; ovicells small, globular or cucullate.

No. 13. M. HIANS group.—With denticular plate in the aperture. Rosette-plates fairly numerous. Zoarium may be unilaminate or bilaminate in the same species. Perhaps this group should be removed from *Membranipora.*

No. 14. ONYCHOCELLA ANGULOSA group.—Avicularia vicarious; ovicell, which is known in very few cases, is small, shallow. This group was abundant in the Tertiary and Cretaceous formations.

No. 15. MEMBRANIPORELLA.—There are pore-chambers. The thick operculum is attached to the front membranous wall, and is in no way connected with the overarching ribs. In *Cribrilina* the ribs form the front wall and the "complete" operculum fits into the corresponding calcareous aperture. *Membraniporella* is closely allied to Group 5, and this again dovetails into Group 7. The *Membraniporellæ* will be more fully studied when the Cribrilinidæ are taken in hand.

In most of these temporary groups many species are doubtfully placed, but there are some characters in common, and in this way we can gradually become better acquainted with the relationships. On the other hand, as we cannot definitely fix the groups, it seems better not to give new generic names.

The areolated spaces which are found in *M. acuta*, H., *M. craticula*, Alder, *M. circumclathrata*, H., *M. sejuncta*, MacG., as well as in *Chorizopora*, do not seem to furnish a character upon which a group can be formed.

After removing from *Membranipora* the two species *roborata* to *Flabellaris*, and *serrata* to *Flustra*, I have tried to group the Membraniporidæ with the aid of all the characters available, including the rosette-plates and the form of the ovicells. Generic division is at present somewhat risky, and the groups now given should be checked by a study of the larva, an examination of the intertentacular organ, the anatomy of the polypide, and special attention should be given to the primary zoœcia. My material has not enabled me to make a comparative study of this last point, and a recent visit to the Zoological Station at Villefranche, where I hoped to make preparations from well-preserved recent material, was disappointing, as there seems to be very few *Membraniporæ* in the Bay.

There are 12 tentacles in *M. pilosa*, L.; 20 in *M. membranacea*, L.; 15 in *M. roborata*, H.; 23 in *M. falcifera*, B.; about 16 in *Chaperia cervicornis*, B.; 14 in *Onychocella angulosa*, Reuss; 14 in *M. flustroides*, H.; 14–16 in *Membraniporella nitida*, Johnst. (*fide* H.).

Through the kindness of Mr. Kirkpatrick I have been able again to look through the mounted *Membraniporæ* of the 'Challenger' collections, and have been able to make corrections in 'Challenger' *M. lineata*, *M. umbonata*, *M. curvirostris* var., *M. crassimarginata*, *M. incrustans*, *M. perfragilis*.

I have again carefully examined my Mediterranean specimens for the purpose of revision, and Miss Jelly has sent me several from South Africa and other localities; and Mr. J. Yates Johnson has submitted a few from Madeira.

The tables of geographical distribution will seem incomplete, but where there was reasonable ground for doubt or any uncertainty the localities are omitted; and with regard to nearly all the older names it is impossible to know what was meant, and these are dropped. Also, unfortunately, with many frequently quoted and recently described species the same difficulty occurs. Many fresh localities are added from my own collections and from other opportunities of comparison.

In making geographical divisions we have to be largely guided by the consideration as to where the Bryozoa have been carefully studied, and I have placed the British forms with Arctic and Scandinavian forms under "Northern." Under "Australasian" I place forms found in the neighbourhood of Australia and New Zealand. In the Atlantic and Pacific column N. or S. indicates that the species is found in the northern or southern hemisphere.

**p* means that at the base of the zoœcium there are pore-chambers.

**np* means no pore-chamber.

(1) or (*s*) signifies one or several pores in the rosette-plates.

	Ovicells.	Avicularia.	Rosette-plates. Distal.	Rosette-plates. Lateral.	Mediterranean.	Northern.	South African.	S. of S. America.	Australasian.	Indian Ocean.	Atlantic.	Pacific.	Fossil.
No. 1. Chaperia Group.													
C. acanthina, Quoy & G.	unknown.	0	2	4–6	...	...	...	*	* Z.	S.	...	...	*
spinosa, MacG.	unk.	0	...	several.	...	...	...	...	*				
cervicornis, Busk	galeriform.	small.	2	elong.	...	...	*	...	*	?	...	...	*
annulus, Manzoni	bar.	pedic. or adnate.	2	4-6?	...	...	...	*	...	S.	...	...	*
annulus, var. *bilaminata*, nov.	bar.	pedic.	2	2 (*s*)	...	...	*						
albispina, MacG.	unk.	0	...	...	...	...	...	...	*				
capensis, Busk	unk.	0	2(*s*)	2	...	...	*						
? *elliptica*, B. (*Foveolaria*)	subglob.	elong.	1	4	...	...	...	...	*				
? *cylindracea*, B. (*Electra*)	galeate.	erect.	4?	...	...	...	...	...	...	S.			
? *tripunctata*, Waters	smooth.	large raised, and small triangular.	...	2	...	...	...	...	*	...	...	...	*
No. 2. Pyripora Group.													
P. catenularia, Jameson	unk. recent.	0	...	2?	*	*	...	...	*	...	...	...	*
polita, H.	unk.	0	...	...	...	...	...	...	*				
confluens, Reuss	unk. recent.	0	...	...	...	...	...	...	*				
eburnea, H.	unk.	0	...	...	...	...	...	...	*				

No. 3. M. PILOSA GROUP (*Electra*).													
M. pilosa, L.	unk.	0	1 (*s*)	4	*	*	...	...	*	...	N.	...	*
—, var. *flagellum*, MacG.	unk.	0	...	...	...	...	...	...	*				
distorta, Hks.	unk.	0	...	...	...	...	...	...	...	N.			
? *monostachys*, Busk	unk. ; ? ovicells in fossils.	0	...	...	...	*	...	...	...	...	...	...	*
bellula, Hincks	unk.	0	...	...	...	...	...	...	*	N. & S.	N.		
tenella, Hincks	unk.	0	...	...	...	...	...	...	...	...	N		
No. 4. M. MEMBRANACEA GROUP.													
membranacea, L.	unk.	0	2	2–4 (L.)	...	*	* (W)	...	*	...	...	...	*
danica, Levinsen	unk.	0	2 (*s*)	4 (*s*)	...	*							
inca, d'Orb.	unk.	0	...	...	...	..	...	...	...	...	...	S.	
villosa, Hincks	unk.	0	...	...	...	.	...	...	...	...	..	N.	
isabelliana, d'Orb.	unk.	0	...	...	...	...	...	*					
pura, Hincks	unk.	0	3 or sometimes 2.	4 irreg.	...	...	...	...	*				
tehuelcha, d'Orb.	unk.	0	numerous.	4–6	...	...	...	*	...	N.	N. & S.	N.	
—, var. *intertuberculata*	unk.	0	...	4	...	...	*						
nitens, Hincks	unk.	0	2 ?	2	...	...	...	...	*				
hydasi, Jullien	unk.	0	...	...	...	...	...	*					
tuberculata, Ort. (non Busk)	unk.	0	...	...	...	...	...	...	...	...	...	N.	
No. 5. M. CORBULA GROUP.													
corbula, Hincks	rib & umbo.	vicar.	1 elong.	4 ? ; **p*	...	...	...	...	*				
pyrula, Hincks	rib.	vicar.	1	4 ; **np*	...	...	...	...	*				
[1] *inarmata*, Hincks	no rib.	0	1 ; **p*	4	...	...	...	...	*				

[1] *M. pectinata* is thought to be only a variety.

	Ovicells.	Avicularia.	Rosette-plates. Distal.	Rosette-plates. Lateral.	Mediterranean.	Northern.	South African.	S. of S. America.	Australasian.	Indian Ocean.	Atlantic.	Pacific.	Fossil.
No. 5 Group—*cont.*													
M. maderensis, sp. nov.	rib.	vicar.	1 (1) * *np*	4 (1)	...	...	...	...	...	...	N.		
sceletos, Busk	smooth.	oval.	3 ; * *np*	8–10	...	...	...	...	...	...	N.		
minuscula, Hincks	shallow.	semi-circul.	...	...	...	...	...	...	...	...	...	N.	
? *longicornis*, H.	unk.	vicar.											
defensa, Kirkp.	unk.	0	...	...	...	...	...	...	...	S.			
corniculifera, Hincks	smooth.	minute.	...	...	...	...	...	...	...	...	...	N.	
No. 6. M. echinus Group.													
echinus, Hincks	unk.	pedic.	...	...	...	...	...	...	...	...	...	N.	
echinata, d'Orb.	unk.	pedic. & sessile.	...	...	...	...	...	...	...	...	...	N. & S.	
Carteri, H.	unk.	artic.	...	...	...	...	...	...	*				
cymbæformis, Hincks	unk.	pedic.	...	...	...	*							
rubida, Hincks	unk.	spatul. & triang.	...	...	...	...	...	...	*				
No. 7. M. lineata Group.													
lineata, L.	rib.	acute.	1 (*s*)	4	* (*fide* Heller)	*							
spinifera, Johnston	rib.	pedicel.	..	...	...	*							
craticula, Alder	rib.	acute.	3	4	...	*							
unicornis, Fleming	rib.	acute.	16–20 (L.)	4 (*s*)	...	*							
flustroides, Hincks	cap.	oval.	...	6	*	*	...	...	...	...	N.		

aurita, Hincks	rib.	2	1; **p*	4; **p*	...	*							
horrida, Hincks	rib.	linguiform.	...	...	...	...	...	...	...	...	...	N.	
Dumerilii, Aud.	no rib.	triang.	1; **p*	4	*	*	...	...	...	...	N.	...	*
Sophiæ, Busk	rib.	prox.; 2 distal.	...	4	...	*	...	...	...	...	N.	...	*
? *Lacroixii*, Aud. & Busk	unk.	0	1 (*s*)	2–3	...	*	...	* R.	*	...	N. & S.		
californiensis, sp. nov.	rib.	triang.	...	...	...	...	...	...	...	...	...	N.	
No. 8. M. patellaria Group.													
patellaria, Moll.	cucul.	0	1	2	*	...	...	...	...	...	N.	...	*
—, var. *multijuncta*, Waters	unk.	0	1	4	*	...	...	...	*				
radicifera, Hincks	large.	unilat.	1	2	...	...	...	...	*				
[1] —, var. *intermedia*, Kirkp.	cucul.	cervic.	1	2	...	...	...	...	*	...	...	N.	*
mauritiana, Kirkp.	cucul.	0	...	several.	...	...	...	...	...	S.			
? *marginalis*, Kirkp.	smooth.	0	...	...	...	...	...	...	...	S.			
? *bidens*, Hagenow	granul.	0	...	6	*	...	...	...	...	...	...	...	*
With areolated spaces.													
circumclathrata, H.	with rib.	triang.	...	...	...	...	...	...	...	...	...	N.	
acuta, H.	smooth; no rib.	tubercul.	1	4	...	...	...	...	*				
discreta, H.	no rib.	0	...	...	...	*							
sejuncta, MacG.	smooth.	oval.	1	4	...	...	...	...	*				
No. 9. M. Flemingii Group.													
Flemingii, Busk	[2] area.	triang.	1	4	...	*	...	...	*	...	...	...	*
—, var. *minax*, Busk	area.	subop.	1; **p*	4 elong.	*	*	*	...	*	...	...	...	*
sigillata, Pourt.	glob.	elong. & proxim.											
trifolium, S. Wood	triang. area.	acute.	2	4	...	*	...	...	* Tahiti	...	N.	...	*
argentea, MacG.	glob. area.	elong.	1	4	...	...	...	...	*				
umbonata, Busk	[2] glob. area.	rostriform.	1; **p*	4	...	...	...	...	*	...	S.		

[1] Described in the same year by Ortmann as *Tremopora dendracantha*, Ort. Jap. Bry.-Fauna, p. 29, pl. ii. fig. 6.
[2] Ovicell with operculum.

	Ovicells.	Avicularia.	Rosette-plates. Distal.	Rosette-plates. Lateral.	Mediterranean.	Northern.	South African.	S. of S. America.	Australasian.	Indian Ocean.	Atlantic.	Pacific.	Fossil.
No. 9 Group—*cont.*													
M. granulifera, H.	unk.	pair.	1; **p*	4	...	...	...	...	...	...	N.		
papillata, B.	unk.	small, prox.	...	...	...	...	...	...	*				
? *cornigera*, B.	glob.	oval.	...	...	...	*							
? *punctigera*, H.	area.	pair, triang.	several.	...	...	...	...	...	*				
? *Rosselii*, Aud.	area.	0	1	3	*	*	...	...	...	...	...	...	*
? *nodulosa*, Hincks	smooth, shallow.	0	...	...	...	*							
? *imbellis*, Hincks	area.	0	2	4	...	*							
? *setigera*, Hincks	unk.	0	...	...	...	..	...	...	*				
No. 10. M. tenuirostris Group.													
tenuirostris, Hincks	round, granul.	elong.	1; **p*	2	*	...	...	...	...	...	N. & S.	N.	*
curvirostris, Hincks	prominent.	curved.	1	8	*	*	...	*	...	..	S.		
gregaria, Hell.	imm.	elong.	2	8	*								
albida, Hincks	cucull.	curved.	...	. .	...	..	...	...	...	S.			
plana, Hincks	large.	elong.	...	...	...	...	...	...	*				
No. 11. M. crassimarginata Group.													
crassimarginata, Hincks	cap-like.	vicarious, spatulate.	1	4	*	...	...	...	...	..	N.		

crassimarginata, var. *japonica*, Ort.	granul.	vicarious.	...	...	...	...	...	...	...	...	...	N. Japan.	
solidula, Hincks	raised.	0	1	2	*								
papulifera, MacG.	unk.	vicarious.	1	2	...	...	...	...	*	...	...	...	*
sculpta, MacG., var. *cucullata*, nov.	large, area.	vicarious.	...	...	...	...	...	...	* N.Z.				
? *marginella*, Hincks	unk.	vicarious.	...	...	...	...	...	...	...	N.			
? [1] *valdemunita*, Hincks	rib.	oval, vicarious.	1	2	...	...	...	...	*				
No. 12. M. CORONATA GROUP.													
coronata, Hincks	unk.	triang.	...	...	...	...	...	*	...	...	...	N.	
incrustans, Waters	globular.	small, triang.	...	...	...	...	...	...	...	...	S.		
albida, Hincks	cucull.	advent., triang.	...	...	...	...	...	...	...	N.			
[2] *levata*, Hincks	smooth or umbo.	small, triang.	1; *p	8	...	...	...	...	*	...	...	N.	
? *minuscula*, Hincks	area.	oval.	...	...	...	...	...	...	...	...	...	N.	
? *armata*, Haswell	unk.	elong.	...	numerous.	...	...	...	...	*	...	...	N.	
No. 13. M. HIANS GROUP.													
hians, Hincks	large, raised; no area.	1–2	about 6	about 6	...	...	...	*(J.)	*	...	...	...	*
? *appendiculata*, Rss.	do.	numerous.	several.	8	...	...	...	...	...	...	...	...	*
Savartii, Aud.	unk.	0	numerous.	4	...	...	...	...	*	N.	N.	N.	*
hians, var. *occultata*, Waters	unk.	small.	...	...	...	...	...	...	*	...	...		*
imbricata, Busk	unk.	erect.	...	irregular, several.	...	...	*						
? *permunita*, Hincks	rib.	vicarious.	4 to several.	about 6	...	...	...	...	*	...	..	...	*

[1] Sometimes has marginal spines.

[2] = *Biflustra sericea*, MacG.

	Ovicells.	Avicularia.	Rosette-plates.		Mediterranean.	Northern.	South African.	S. of S. America.	Australasian.	Indian Ocean.	Atlantic.	Pacific.	Fossil.
			Distal.	Lateral.									
No. 14. ONYCHOCELLA GROUP.													
O. angulosa, Reuss.	unk.	vicarious.	1	2	*	...	...	...	...	...	N.	...	*
? *velata*, Hincks.	shallow.	vicarious.	...	...	...	...	...	...	...	...	...	N.	
? *normaniana*, d'Orb., =*favus*, Hincks	unk.	0	...	...	...	...	...	...	...	...	...	N.	*
? *bursaria*, MacG.	...	...	...	...	...	...	...	...	*				
—, var. *phillipensis*, nov.	unk.	vicarious.	2	2	...	...	...	...	*				
No. 15. MEMBRANIPORELLA.													
M. Agassizi, Smitt	rib.	pair, small.	...	...	...	...	...	...	...	...	N.		
Aragoi, Aud.	unk.	0											
crassicosta, Hincks.	unk.	0	...	...	...	...	...	...	...	...	N.		
distans, MacG.	glob.	0	...	...	...	...	...	...	*	...	...	...	*
melontha, Busk	unk.	0	...	...	...	*							
nitida, Johnst.	subglob.	triang.	4 ; * *p*	1	...	*	...	..	...	...	N.	...	*

INCERTÆ SEDIS.													
M. amplectens (*Heteroœcium*), Hincks ...	special cell.	0	...	...	...	...	...	...	*				
capriensis, Waters	cucull.	0	...	...	*								
operculata, Hincks........................	unk.	0	...	...	*								
terrifica, Hincks	unk.	large, sub-oral.	...	...	...	...	...	*					
arctica, d'Orb.	raised.	2 kinds.	...	...	...	*							
protecta, Hincks	unk.	elong.	..	...	...	...	...	...	...	...	...	N.	
exilis, Hincks	unk.	oval.	...	...	...	...	...	...	...	...	...	N.	
vitrea, Hincks..............................	smooth.	0	...	...	...	...	...	...	...	...	...	N.	
tubigera, Busk (*Foveolaria*)	area.	median and others.	6	10	...	...	*						
elizabethiensis, Waters	area.	several.	numerous.	8	...	...	*						
falcifera, B. (*Foveolaria*)	unk.	winged.	1	4	...	...	*						
perfragilis, Hincks........................	unk.	vicar.	3[1]	2	...	...	...	...	*	S.	...	N.(J.)	*
bicolor, Hincks	unk.	0	...	...	...	...	...	...	*				
inornata, Hincks	unk.	0	...	...	...	...	...	...	*				
macilenta, Jullien	glob., gran.	minute.	...	...	...	...	...	...	...	...	N.		
eburnea, Hincks	unk.	0	...	...	...	...	...	...	*				
Haswelli, Hincks	unk.	0	...	...	...	...	...	...	*				
patula, Hincks	cucull.	triang.	...	...	...	..	...	...	...	...	...	N.	
bengalensis, Stol.	...	0	brackish water.	...	...	...	...	...	...	*			

[1] The distal rosette-plates are near the front wall, which is an unusual position. Occasionally the middle one is absent.

Flabellaris roborata (*Hincks*). (Pl. 48. figs. 10–11: Pl. 49. figs. 7–10.)

This was called *Membranipora* by Hincks, but MacGillivray subsequently created the genus *Craspedozoum*, on account of the bundle of chitinous tubes at the border of the zoarium, though as bundles of tubes occur in such different forms as *Diporula marginata*, several *Flustra* and *Euthyris*, *Caberea*, *Flustramorpha*, &c., I was unable to accept the genus and left it provisionally under *Membranipora* (Ann. & Mag. Nat. Hist. ser. 5, vol. xx. p. 183, 1887), and Hincks on the same grounds in 1892 (*op. cit.* vol. ix. p. 331) also left it with *Membranipora*.

MacGillivray places it in the family Flustridæ, and Busk, in his 'Challenger' Report, did not recognize that it had been described, and called it *Flustra membraniporides*. The internal shape of the zoœcia does not correspond with that of any *Flustra*, nor do I now think that, on the ground of internal structure, it can be left with *Membranipora*.

The shape of the zoœcia and the character of the rosette-plates is the same as that of *Menipea triseriata*, Busk; but as I have pointed out in this Journal (vol. xxvi. p. 2), *Menipea triseriata*, *flabellum*, *ternata*, &c. must be removed from *Menipea*. *M. roborata* is sub-articulated and the others are distinctly articulated. I have provisionally called the group *Flabellaris*, as *M. flabellum* is a characteristic member of it.

If the name *Cellularia* had not been so bandied about it might have been retained, but now this would cause confusion.

The ovaria are near the distal end, close to the basal wall, but situated about the same distance from the two side walls, and consist of a large number of ova round the border of the ovarium. The position is unusual. Near the ovarium there are small groups of nucleated cells, connected by the general parenchym.

As already said, the zoœcia dovetail into one another (Pl. 48. fig. 11) so that the lower part of the younger zoœcia comes under the aperture of the older ones. The rosette-plate on the distal wall spreads out at each end and nearly meets in the middle (Pl. 49. fig. 9). Perhaps it is derived from a form which had two rosette-plates. There are internal denticles (Pl. 48. fig. 10) which do not seem to have any knob or head, and sometimes look as if they were the continuation of the distal wall. There is no bar across the avicularium.

In the variety *F. ligulata*, MacG., there is one avicularium

above the aperture, except in the ovicelligerous cells, when there are two. In the *F. roborata*, MacG., there are usually two, though frequently only one above the aperture, and the marginal zoœcia only have one avicularium. In *F. ligulata* the external zoœcia have small lateral avicularia, resembling those of *F. triseriata*, B. In some specimens of *ligulata* no spines occur, in others they are fairly general.

The *F. roborata*, typica, occurs living from Victoria, New South Wales, and Bass's Straits. The var. *ligulata* from Victoria and New Zealand, and fossil from Waurn Ponds.

F. spicata, MacG. Living: Victoria.

CHAPERIA SPINOSA (*MacG.*) (non *d'Orb.*, non *Jullien*).

Membranipora spinosa, *MacG., Zool. Vict.* dec. xiii. p. 107, pl. 127. fig. 8.

Mr. Kirkpatrick has called attention to the fact that Quoy & Gaimard did not call their "epineuse" *Membranipora spinosa*, but *acanthina*, therefore MacGillivray's name can stand. It has the spines more delicate and more numerous than in *C. acanthina*, and they stand erect, more or less in a bundle, as described by MacGillivray.

The rosette-pores are numerous, forming a line along the middle of the wall.

Loc. Vaucluse Point (N. S. Wales), Victoria.

CHAPERIA ANNULUS (*Manzoni*).

Membranipora annulus, *Manzoni, Bry. foss. Ital.* 4a cont. p. 7, pl. i. fig. 6 (?); *Bri. di Castrocaro*, p. 12, pl. i. fig. 9; *Waters, "Tert. Chil. Bry. from New Zealand," Q. Journ. Geol. Soc.* vol. xliii. p. 47, pl. vi. figs. 2, 5, & 9.

Amphiblestrum annulus, *MacGillivray, Tert. Polyz. of Victoria*, p. 43, pl. vi. fig. 3.

Membranipora galeata, *Busk, Brit. Mus. Cat.* p. 62, pl. lxv. fig. 5; *"Zool. of Kerguelen," Phil. Trans.* clxviii. p. 195; *Zool. Chall. Exp.* pt. xxx. p. 64.

Membranipora dentata, *Waters, Q. Journ. Geol. Soc.* vol. xxxviii. p. 263, pl. viii. fig. 14.

Amphiblestrum cristatum, *Busk, Zool. Chall. Exp.* pt. xxx. p. 65, pl. xv. fig. 1.

This was at first described by Manzoni from very unsatisfactory specimens, but in the same author's later work recognizable figures were given, and in my paper on New Zealand fossils I showed that it is subject to considerable variation.

The name *galeata* is the oldest, but from the description and figure in the British Museum Catalogue identification has not been made, and I should not have recognized it as a synonym without an examination of the Museum specimen. The *M. cristata* of the 'Challenger' should perhaps be considered a variety on account of the pedicellate suboral avicularium.

Loc. Living: Swains Bay, E. Falkland, in 4–10 fath.; Stat. 149 D, Kerguelen Island (*Chall.*). Fossil: New Zealand; Australia; the Pliocene of Italy and Sicily.

CHAPERIA ANNULUS, *Manzoni*, var. BILAMINATA, nov. (Pl. 47. figs. 5, 8, 9.)

? Amphiblestrum cristatum, *Busk*, '*Challenger*' *Report*, vol. x. p. 65, pl. xv. fig. 1 (type).

From Port Elizabeth, S. Africa, I have a bilaminate *Membranipora*, which in its chief characters corresponds with Busk's *Amphiblestrum cristatum.*

The zoarium is massive, contorted. The opesia is oval, depressed, with an internal lateral plate on each side, as in *C. spinosa*, Q. & G. On each side there is a large oral bifurcate spine, besides a smaller spine, which, however, is not always distinguishable in ovicelligerous zoœcia; below the opesia there is a large pedunculate avicularium. The ovicell is widely open in front, and is closed by its own operculum, which has a straight lower edge. On the ovicell there is an area with a raised border to it, and it does not absolutely correspond with the ovicell of typical *M. cristata.* On the summit of the ovicell there is an elongate raised avicularium, but when the ovicell is not developed there is a similar avicularium in its place. There is no complete bar across the avicularium.

There are two large lateral rosette-plates (that is, one to each neighbouring zoœcium) with numerous pores. They are situated moderately near the front wall of the zoœcium, and seem to be more or less in chambers.

The type specimens from St. 149 'Challenger' have a spine below the opesia at the edge of the lamina.

MEMBRANIPORA TEHUELCHA (*d'Orb.*). (Pl. 48. figs. 6–8.)

Flustra tehuelcha, *d'Orb. Voyage dans l'Amér. mérid.* vol. v. p. 4, p. 17, pl. viii. figs. 10, 14.

Membranipora tuberculata, *Busk, Quart. J. Micr. Soc.* vol. vi. p. 126, pl. xviii. fig. 4.

The first clear description of this common and widely distributed species was given by d'Orbigny in 1842 (the date on the *part* of the volume), but Busk in his paper considered this was the *tuberculata* of Bosc. Bosc gave no figure, and the description, which is most meagre, seems more probably to refer to *M. pilosa*. His giving the locality European Seas makes this probable, though it is quite possible that he confounded more than one species. *Flustra dentata*, Müller, which he gave as a synonym, has been considered to be a variety of *pilosa*. Although this form is so common, it has never been thoroughly described, nor have I had the opportunity of examining any spirit-specimens.

Mr. Kirkpatrick called my attention to two comb-like processes (Pl. 48. fig. 7) in the interior of a specimen from Angola, which I at once perceived must be compared with the single comb-like process in *M. nitens* (Pl. 48. fig. 5); but although they may be spoken of as generally occurring in the specimens from this locality, it does not seem to be a character upon which a new species can be founded, as it exists in *M. tehuelcha* from other localities, though often in an aborted form.

The stalks supporting these combs arise from the lower part of the front calcareous wall very near the distal border. It is directed downwards, spreads out laterally, and carries a number of fine pointed teeth (5–12). In specimens from Angola and San Pedro, these combs are found generally, and there are usually a pair, though one only occurs in some zoœcia, especially in those from which two * zoœcia grow, also occasionally there may be three combs. The zoœcia are almost divided into two parts by these stalked combs. In the Kurrachee specimens there are aborted stalks in the same position, but the serrate structure is wanting, while in the specimen from California I do not find either stalk or comb.

The position of the combs in *M. tuberculata* and *M. nitens* is much the same as that of the denticle in *M. hians* and *M. Savartii*. Until living specimens are examined, the function may remain obscure, and from the position in the posterior part of the zoœcium it hardly seems probable that it is the protection of the ova.

There are also numerous small cervicorn spines or rays projecting inwards from the walls near the base. These remind us

* In other species where there are a pair of tubercles or avicularia, the same economy is frequently exhibited.

of the spines inside the zoœcial tubes of *Lichenopora* *, *Entalophora*, and other genera of Cyclostomata, and there are also spines projecting from the internal walls of *Flustra dentigera*, *denticulata*, and *spinuligera*.

There are four or six lateral rosette-plates, and numerous distal ones at the base of the distal wall. The appearance differs considerably in various parts of a colony and in different colonies, as the tubercles are sometimes small, at other times very large, and two frequently merge into one, as figured by d'Orbigny.

Biflustra jugalis, MacGillivray, seems to be closely allied, and if *M. Hyadesi*, Jullien, has to be separated, it would only be as a variety. *M. danica*, Levinsen, belongs to this group, also *M. bimamillata*, MacG., a species which I have not seen, and I do not understand what MacGillivray says about the denticle. *M. denticulata*, Smitt (Floridan Bryozoa), may be a variety.

There is a tendency for the lateral walls to be broken through by the action of the waves, but they frequently become cemented together again. The same is the case in *M. membranacea* (Pl. **49**. fig. 17), and in both species the break occurs in approximately the same position. In neither do I see any trace of the separate plates which Nitsche describes.

Loc. California (given by *Miss Jelly*); Angola; Chagos Island; San Pedro, Pernambuco; Senegal; Kurrachee (*Brit. Mus.*); Rio de Janeiro (*MacG.*); Madeira (*Busk*); Patagonia (*d'Orb.*). Gulf-weed generally.

MEMBRANIPORA TEHUELCHA, var. INTERTUBERCULATA, nov. (Pl. **48**. figs. 1, 2.)

Specimens from Port Elizabeth, S. Africa, have the border very much raised, so that the membrane carrying the operculum is much depressed. On the lateral wall, besides the tubercle there is a projecting process, and it is upon this and the depression that the variety is based.

The tubercles vary much in shape and character, and it is almost impossible to give a faithful representation. The walls are much thinner than in the figures, which must be looked upon as somewhat diagrammatic to show the main characters.

The minute denticles or rays occur near the base as in typical *tehuelcha*. There are no ovicells or avicularia, and on the lateral wall there are four rosette-plates.

* See Waters, "Tert. Cycl. Bry. from New Zealand," Quart. Journ. Geol Soc. vol. xliii. p. 340, pl. xviii. figs. 5 & 6.

Membranipora nitens, *Hincks*. (Pl. **48**. figs. 3, 4, 5.)

M. nitens has a comb-like process borne on a broad stalk which projects downward into the zoœcium, and this is referred to when dealing with the pair of fringed processes in *M. tehuelcha*.

Membranipora maderensis, sp. nov. (Pl. **48**. fig. 19.)

Zoarium incrusting, with tendency to form separated lines of cells. Zoœcia oval, slightly produced below the area; opesia oval, margin raised, very thick, sloping inwards. Six oral spines; usually five delicate marginal spines. Avicularia vicarious, with an avicularian chamber resembling in the lower part an ordinary zoœcium, but with fewer spines. The distal end of the avicularian chamber is raised and serrate; in this is situated the large semicircular mandible, on which a dark curved line forms a small arc. The ovicell has a rib, and on the ovicellular zoœcia there are two oral spines.

This in most characters corresponds with a common form from New South Wales which I consider is *M. corbula* (Pl. **48**. fig. 20), but in that the six oral spines are much stouter and the marginal spines are more numerous. It is extremely probable that Jullien had a specimen of this species before him when he described *M. tenuis*, but the spines had been lost. He speaks of only one zoœcium being intact.

Loc. Madeira (*J. Y. Johnson's collection*).

Membranipora sceletos (*Busk*). (Pl. **49**. figs. 2–6.)

Lepralia sceletos, *Busk, Quart. Journ. Micr. Soc.* vol. vi. p. 262, pl. xx. fig. 3.

Membranipora sceletos, *Hincks, Ann. Mag. Nat. Hist.* ser. 5, vol. vi. p. 73.

It is impossible to give a figure faithfully representing this extremely beautiful species, as under the microscope we are looking down upon the narrow edge of the flattened spines. I hope, however, that my figure will explain the "pedunculated plate" at each side of the aperture, also the way in which the spines when they meet in the middle bend aside instead of ankylosing in the central line. It will be seen from figs. 3 and 4 that the pedunculated plate is divided at the top, forming two or three lobes. This looks like the commencement of a cervicorn process. The avicularia and the mandibles are very similar to those of *M. flustroides* (Pl. **49**. fig. 12).

Loc. Madeira.

MEMBRANIPORA LINEATA (*L.*). (Pl. 47. fig. 11; Pl. 48. fig. 9.)

Membranipora albida, *Busk* (*pars*), *Zool. Chall. Exp.* pt. xxx. p. 63.

Busk's *M. albida* of the 'Challenger' Report was for a long time a great puzzle, as it seemed in some respects to be closely allied to *M. curvirostris*; but as the figures and description did not correspond, it was not until after an examination of the 'Challenger' specimens that I was able to clear up the difficulty. Busk had two quite distinct forms before him, and the one was figured natural size, while the magnified figure is principally taken from the other specimen. The present form from the Azores has numerous spines round the border, say 10 on each side, and in having so large a number varies from the European *M. lineata*; the avicularia, however, are similar.

Probably *M. lineata* will turn out to be only a northern form.

The specimens from New South Wales, which I considered to be a variety, is the *M. sejuncta* of MacGillivray. Specimens so named from New Zealand are not the *M. lineata*. Heller mentions it from the Adriatic, but I have not seen it from any Mediterranean locality.

I have already alluded to the pointed teeth within the pore-chamber, and give a figure to explain their position (Pl. 48. fig. 9).

Loc. Station 75, Azores ('*Challenger*').

MEMBRANIPORA FLUSTROIDES, *Hincks*. (Pl. 49. fig. 12.)

Membranipora flustroides, *Hincks, Ann. Mag. Nat. Hist.* ser. 4, vol. xx. pp. 213, 214; *Brit. Mar. Polyzoa*, p. 151, pl. xix. fig. 2.

Membranipora nodulifera, *Hincks, Ann. Mag. Nat. Hist.* ser. 5, vol. vi. p. 71, pl. ix. fig. 2.

The specimens from Capri and Villefranche-sur-Mer have lost the spines, and the zoœcia are somewhat longer than those of the British specimens, but the oval avicularia are in shape and position similar. In a specimen in Mr. J. Yate Johnson's collection from Madeira, the spines are not so broad as those figured by Mr. Hincks, but neither are they in an undoubted *M. flustroides* sent to me by the Rev. A. M. Norman marked "Britain," though in this specimen occasionally a broad one is seen.

This approaches the *Flustra* type, and is closely allied to *M. lineata*.

Loc. Britain, Capri, Villefranche-sur-Mer, Madeira.

Membranipora Lacroixii, *Aud. & Busk.* (Pl. 48. figs. 14, 15.)

Membranipora Lacroixii, *Busk, Brit. Mus. Cat. Mar. Polyz.* p. 60, pl. lxix. figs. 1–3; *Hincks, Brit. Mar. Polyz.* p. 129, pl. xvii. figs. 5–8.

Busk was the first to refer the British species to Audouin's figure, but I am not quite sure what was meant by Audouin, and have not seen anything from the Mediterranean which, according to the methods adopted in preparing this paper, corresponds with the English form. Audouin's figure may have represented a specimen of *M. crassimarginata* in which no ovicells or avicularia were found, and frequently in considerable pieces of that species none occur, and it is very easy to be misled by such a specimen.

Pergens put *M. Lacroixii* under *M. reticulum*, L. This may have been the species Linné had before him, but none of the early descriptions assist us in identification, as there are many species which would just as well fall in with the meagre diagnosis, and the figure given by Esper is equally useless.

Busk says the *M. Lacroixii* and *M. Savartii* are synonyms, and Pergens also places them both under *reticulum*, but we now know that the rosette-plates and growth of these two species are quite different. It is possible that a fuller study of a series of *M. Savartii* may bring out new points. In spite of doubts it is proposed to retain, for the present, the name *Lacroixii* for the species described by Busk.

The dorsal surface of the British *M. Lacroixii* is very characteristic (Pl. 48. fig. 14). In the calcareous basal wall near the distal end there is on each side a transparent circle, and sometimes there are other small ones, and the lateral walls throw out irregular projections, while on the distal walls there are two projections opposite those on the next zoœcium (fig. 14).

The interesting point about this is that specimens from New Zealand correspond in all these minute particulars. It seems to be fairly common from New Zealand, and some spinous specimens of *Lacroixii* were at first placed under *M. lineata*, a species which I now believe to be only a northern form.

The operculum has a membranous extension beyond the chitinous arch (fig. 15), and in this respect is similar to that of *M. hians* and *M. hians* var. *ocellata*, W. As shown by Pergens, the shape and size of the zoœcia are subject to great variation.

Loc. Britain, New Zealand, and fossil.

Membranipora Dumerilii (*Aud.*).

For synonyms see Hincks, Brit. Mar. Polyz. p. 156; and Waters, "North Italian Bryozoa," Q. Jn. Geol. Soc. vol. xlvii. p. 12, pl. ii. fig. 4.

Membranipora Dumerilii, *Levinsen, Zoologica Danica: Mosdyr*, p. 57, pl. iv. figs. 22–25.

In both the Rapallo and British specimens there is often a space between the zoœcia, about the size of a zoœcium, and it is covered by a membrane in the middle of which there is a slit-like or oval opening; and sometimes zoœcia in other respects fully developed have a membranous cover with a similar opening. These curious cells are not confined to the growing borders of a zoarium.

There are 4 lateral and 1 distal pore-chambers.

Loc. North Europe; Britain; Mediterranean (Rapallo, said to be from 26–30 fathoms, also on *Pinna*); Madeira (*J. Y. Johnson's collection*). Fossil: Pliocene and Miocene of Europe, and the Tertiary of New Zealand.

Membranipora Sophiæ, *Busk*, var. armifera, *Hincks*. (Pl. 48. fig. 18.)

Membranipora armifera, *Hincks, Ann. & Mag. Nat. Hist.* ser. 5, vol. vi. p. 82, pl. xi. fig. 5.

When I received from Canon Norman a specimen from the Gulf of St. Lawrence named *armifera*, I at first doubted the determination, as it approached so much more nearly to *M. Sophiæ* than to the specimen described by Mr. Hincks. As a rule there is only one oral avicularium, though sometimes two occur. The spine on the one side is stout, articulate, and truncate, whereas that on the other is delicate and acute. The ovicell is raised, globular with a rib, and is surmounted by a large triangular avicularium. There are usually four lateral "pore-chambers" and several distal pores.

In a specimen of *M. Sophiæ* from the Gulf of St. Lawrence very many of the zoœcia, especially the younger ones, are entirely without any trace of spines.

The *M. Sophiæ*, Busk, is the *Reptoflustrina arctica* of d'Orb. (Pal. Franç. p. 582), and is called *M. lineata* forma *Sophiæ* by Smitt, and *M. arctica* by Lorenz. But d'Orbigny also gave the manuscript name *arctica* to another northern form, which he called *Semiflustrellaria arctica*, and this Smitt has described and figured as *Membranipora arctica*. As d'Orbigny's description of *Reptoflustrina arctica* is very slight and might refer to other species, it will be best to retain for this the name *Sophiæ* of

Busk, and then *M. arctica* can remain for *Semiflustrellaria arctica*, d'Orb. and Smitt, although the name at first was only manuscript.

MEMBRANIPORA CALIFORNIENSIS, sp. nov. (Pl. **49.** fig. 14.)

The oval zoœcia are closely united together, and the border, which is not very thick, is armed with a stout articulated spine on one or both sides somewhat above the middle; below, there are on each side usually two delicate pointed spines.

Below the zoœcium there is a long triangular avicularium often curved to the border of the zoœcium; sometimes this is replaced by a short triangular avicularium. The operculum has a flap somewhat like that of *M. hians*, H., and the ovicell has a thick rib. Having only seen the one specimen from California, sent by Miss Jelly, I have been unable to prepare out the operculum or make any dissections.

Perhaps this should be called a variety of *M. Sophiæ*.

Loc. California (*Miss Jelly*).

MEMBRANIPORA INTERMEDIA, *Kirkpatrick.*

Membranipora radicifera, var. intermedia, *Kirkpatrick, Proc. R. Dublin Soc.* n. s. vol. vi. p. 615, pl. xvi. figs. 1, 2.

Membranipora intermedia, *MacGillivray, Tert. Polyzoa of Victoria*, p. 34, pl. iv. fig. 8.

Tremopora dendracantha, *Ortmann, Die Japanische Bryozoenfauna*, p. 29, pl. ii. fig. 6.

It is very possible that this is the *M. cervicornis* of Haswell (*M. Haswellii*, Hincks).

MEMBRANIPORA BIDENS (*Hag.*). (Pl. **49.** fig. 1.)

Cellepora bidens, *Hagenow, Bry. Maastr. Kreideb.* p. 92, pl. xi. fig. 16.

Cellepora hippocrepis, *Reuss, nec Goldfuss, Foss. Polyp. Wien. Tert.* p. 94, pl. xi. fig. 14.

Membranipora bidens, *Busk, Crag. Polyzoa*, p. 34, pl. ii. fig. 44; *Reuss, Bry. Oest-Ung. Mioc.* p. 183 (43) pl. x. figs. 10, 11; *Manzoni, Brioz. Plioc di Castrocaro*, p. 15, pl. ii. fig. 16; *Waters, "Bry. Plioc. of Bruccoli," Trans. Manch. Geol. Soc.* vol. xiv. p. 467.

Micropora hippocrepis, *Waters, "Foss. Chil. Bry. from Mt. Gambier, S. Australia," Q. J. Geol. Soc.* vol. xxxviii. p. 264.

Periteichisma bidens, *Koschinsky, "Bry. Tert. Bayerns," Palæontographica*, vol. xxxii. p. 27; *Pergens, "Plioc. Bry. von Rhodos," Ann. Naturhist. Hofmuseums, Wien*, vol. ii. p. 17.

As I have elsewhere said, in the specimens dredged off Capri the opercula and other organic parts have disappeared, and thus it has been impossible to study the position of the operculum:

however, I do not now consider that it filled up the opesial space, and this opinion is based upon the similarity of the form of the aperture with that of *M. patellaria* and its allies. In the Crag and other fossil specimens, in some zoœcia the aperture is straight below, while others are distinctly bidentate; and also in the Capri specimens the aperture is generally straight, though the dentate structure can often be distinguished or a broad denticle may be formed in the middle, the front wall slopes down to the distal end.

The whole of the surface of the zoœcia and of the ovicells is minutely granulate. The ovicell is small and but slightly raised, and has a perforation at the top. There are about 6 lateral rosette-plates.

This belongs to a group that was largely represented in the Cretaceous and Tertiary periods; but the genus *Periteichisma* of Koschinsky contains species not closely allied, and if a genus has to be made it must be upon other grounds than those given by Koschinsky.

Loc. Living: Capri, from 220 metres. Fossil: Cretaceous of Ciply, Maestricht, and Foxe; Miocene of Australia; Pliocene, Italy, Sicily, Rhodes, and the Crag.

Membranipora patellaria (*Moll*).

Diachoris patellaria, *Waters, Ann. & Mag. Nat. Hist.* ser. 5, vol. iii. p. 120, pl. x. figs. 6–9.

Membranipora patellaria, *Waters, Q. Journ. Geol. Soc.* vol. xlvii. p. 13.

Adriatic and Naples; Madeira (*J. Y. J. coll.*); Florida. Fossil: the Bartonian of North Italy.

Membranipora patellaria, var. multijuncta, *Waters*.

Diachoris patellaria, var. multijuncta, *Waters, Ann. & Mag. Nat. Hist.* ser. 5, vol. iii. p. 120, pl. xiii. fig. 4.

Amphiblestrum patellarium, *MacGillivray, Zool. Victoria*, decade xii. p. 70, pl. cxvii. figs. 9, 10.

Adriatic and Naples; Victoria.

Membranipora papillata (*Busk*).

Amphiblestrum papillatum, *Busk, Zool. Chall. Exp.* pt. xxx. p. 66, pl. xxxiii. fig. 1.

Membranipora trifolium, form minor, *Hincks, Ann. & Mag. Nat. Hist.* ser. 5, vol. xv. p. 255, pl. viii. fig. 7.

I am not quite sure that the *Membranipora* first described by Hincks from Bahia, as *M. trifolium* form *minor*, is the same as what he subsequently figured from Tahiti under this name, but

think there is no doubt that this last is the same as the 'Challenger' *M. papillata*, of which, however, the figure is somewhat misleading.

The British Museum specimen in the 'Challenger' collection has the base of the opesia nearly straight and the avicularia are oval. It would appear that the avicularia are sometimes pointed and sometimes oval, as specimens in my collection from Tahiti and from "Singapore or Philippines" have pointed avicularia, whereas Hincks says that his specimen from Tahiti had oval ones.

In my specimen just referred to, there are 2 distal rosette-plates and 6 to 8 lateral ones. A specimen in the British Museum from Fernando Noronha seems to be this species.

Loc. Tahiti (*H.*). Station 208, 'Challenger' (Philippine Islands); Fernando Noronha.

MEMBRANIPORA UMBONATA, *Busk.*

The specimen in the British Museum collected by the 'Challenger' from Station 313 (South America), and which Busk cited on page 66 of his report as *M. umbonata*, is *Micropora uncifera*, B.

The other specimen cited from St. 163 *a* (N.S.W.) is *M. umbonata.* The specimen in the British Museum Catalogue collection determined by Busk as *M. umbonata* is *M. uncifera.* Although these two species have a general resemblance, they are readily distinguished by examining the opesia and opercula.

The 'Challenger' specimen from Station 320 (S. Atlantic) is about double the size of a specimen in my possession from "W. Australia," and perhaps they should be separated as varieties.

MEMBRANIPORA GREGARIA, *Heller.* (Pl. 47. fig. 1.)

Membranipora gregaria, *Heller,* "*Die Bryozoen des adriatischen Meeres,*" *Verhandl. der k.-k. zool.-bot. Gesellschaft, Wien,* vol. xvii. 1867, p. 98, pl. i. fig. 8.

Membranipora Flemingii, var. gregaria, *Waters, Ann. & Mag. Nat. Hist.* ser. 5, vol. iii. p. 122, pl. xiii. fig. 5.

The zoœcia are elongate oval, with a large triangular avicularium between the distal end of one zoœcium and the proximal one of the next. The calcareous walls of the zoœcia are, in the Naples specimen, thin and often nearly smooth or only very slightly crenulated. Heller calls the walls moderately thin and granulated in the specimens from Lagosta. The mandible is not curved. The ovicells are immersed, only just showing a slight

elevation below the avicularium, and are readily overlooked. No spines.

Membranipora curvirostris, *Hincks*. (Pl. 47. fig. 2.)

Membranipora curvirostris, *Hincks, Ann. & Mag. Nat. Hist.* ser. 3, vol. ix. p. 29, pl. vii. fig. 4; *Brit. Mar. Polyzoa*, p. 153, pl. xx. figs. 5, 6; *Ridley, Proc. Zool. Soc.* 1881, p. 46.

This and *M. gregaria* approach so closely to one another, that it seemed as if *gregaria* must be considered as a variety, but the more prominent and curved avicularium of *M. curvirostris* enables them to be separated, besides which the discovery of the immersed ovicell in *M. gregaria* further separates them. In the Naples specimen the space above the avicularium is uncovered, as described by Hincks, and a rosette-plate into the avicularian chamber is here visible.

I have in one or two cases found a stout spine at the proximal end of the zoœcium, and also there may be two oral spines, but they very seldom occur in the Naples specimens, and Ridley did not find any in those he examined from Brazil.

Membranipora curvirostris, *Hincks*, var. (Pl. 47. fig. 12.)

Membranipora albida, *Busk* (*pars*), *Zool. Chall. Exp.* pt. xxx. p. 63, pl. xv. fig. 4.

One of the two specimens described in the 'Challenger' Report as *albida* differs from the European *M. curvirostris* in having smaller and less curved avicularia, but the curious uncovered space above the avicularium is equally marked, and except in *M. permunita* I am unaware of the occurrence of these spaces in any other species, and perhaps they must be considered as aborted zoœcia. As the specimen in the 'Challenger' collection at the British Museum has the avicularia less curved than is shown in the figure in the Report, it is possible that Busk may have had the opportunity of examining a second specimen.

My figures of this and of *M. lineata* (Pl. 47. fig. 11), also called *M. albida* by Busk, are prepared from sketches made when I examined the specimens, and are therefore perhaps a little more diagrammatic than if the specimens had been before me.

Loc. Station 172: Nukalofa, Tongatabu; 18–20 fathoms, coral-mud ('*Challenger*').

Membranipora tenuirostris, *Hincks*. (Pl. 47. fig. 7.)

Membranipora tenuirostris, *Hincks, Ann. & Mag. Nat. Hist.* ser. 5, vol. vi. p. 70, pl. ix. fig. 3; *Waters, Journ. Roy. Micro. Soc.* ser. 2, vol. v. p. 5, pl. xiv. fig. 41; *Quart. Journ. Geol. Soc.* vol. xlvii. p. 11.

Membranipora Flemingii, *Waters, Ann. & Mag. Nat. Hist.* ser. 5, vol. iii. p. 122, pl. xiii. fig. 2.

The Naples and Rapallo specimens have not the spines at the side figured by Mr. Hincks, but there is often a small spine at one side below the ovicell. Instead of a bar across the avicularian chamber, there are two large denticles directed towards one another. This species does not show any signs of suboral glands, nor have I found this structure in any of the Membraniporidæ, having cut sections of *M. tenuirostris*, *M. pilosa*, *M. inarmata*, *M. patellaria*, *M. flustroides*, *Onychocella angulosa*.

There is one large distal pore-chamber and two lateral ones, though when the zoœcia are very irregularly placed there may be more, but as a rule it is one rosette-plate to each neighbour.

Loc. Naples; Rapallo; Adriatic; Queen Charlotte Island; Madeira. Fossil: Bartonian of N. Italy.

Membranipora sculpta, *MacG.*, var. cucullata, nov. (Pl. 47. fig. 14.)

Type. Membranipora sculpta, *MacG. Tert. Polyz. Vict.* p. 36, pl. v. fig. 1.

Zoarium incrusting. Zoœcia irregular, more or less oval, with the proximal edge often straight. Margins thick, sloping inwards and downwards, granular, slightly crenulated. Avicularia round, vicarious, the upper part raised, forming a kind of cap. A very distinct bar across the avicularium. Ovicells prominent, with a large area.

This only seems to differ from the fossil *M. sculpta*, from Schnapper Point and Muddy Creek, in not having the avicularium sculptured and in having the upper part raised. The chitinous parts are not preserved in the single specimen examined.

Loc. Charleston, South Island (New Zealand); sent by Miss Jelly.

Membranipora crassimarginata, *Hincks*. (Pl. 47. fig. 4.)

Membranipora crassimarginata, *Hincks, Ann. & Mag. Nat. Hist.* ser. 5, vol. vi. p. 71, pl. ix. fig. 1, & ser. 6, vol. viii. p. 86.

There are specimens from both Naples and Capri, differing, however, from previous descriptions in the character of the ovicells, which are small, cucullate, with a strong thickened

ridge similar to that of *M. solidula*, H. Hincks describes the ovicell as depressed in front, smooth and glossy, whereas Ortmann says the variety *japonica* has the ovicell pitted. The Naples specimens have a linear depression before the ridge, and sometimes this, and not the ridge, is distinguishable.

Although the resemblance is not very striking at first, this is closely allied to *M. solidula* and *M. papulifera*, MacG. The ovicells of Naples *M. crassimarginata*, of recent European *M. solidula*, and of New Zealand fossils are identical. I have previously united *papulifera* with *solidula*, but at that time had not noticed that specimens sent from Victoria as *M. papulifera* have large vicarious avicularia similar to those of *M. crassimarginata*. We thus have as close allies the *M. solidula* of Europe and the *M. papulifera* of Australia and New Zealand (fossil and recent).

I have just had the opportunity of examining a specimen from Madeira (in Mr. J. Y. Johnson's collection), which Mr. Busk had determined as *M. irregularis*, but it turns out to be *M. crassimarginata* with the characteristic vicarious avicularia. Probably the name *irregularis* should be dropped.

A poor specimen in the 'Challenger' collection from Stat. 135*c* (Tristan da Cunha) is probably *M. crassimarginata*, but the other specimens of "*M. crassimarginata*" from the 'Challenger' are placed elsewhere (see *M. perfragilis*).

Loc. Naples, Capri, Villefranche-sur-Mer, Madeira; Tizard (China Sea); Stat. 135 'Challenger,' Tristan da Cunha; var. *japonica*, Japan.

MEMBRANIPORA INCRUSTANS, nom. nov. (Pl. 47. fig. 13.)

Membranipora crassimarginata, var. incrustans, *Busk* (*pars*), *Zool. Chall. Exp.* pt. xxx. p. 63.

Membranipora Dumerilii, *Waters*, *Supp. Rep. Zool. Chall. Exp.* vol. xxxi. pt. lxxix. p. 12.

Zoarium incrusting. Zoœcia oval, marginal border sloping inwards, crenulate; immediately above each zoœcium, and on the same level, a small avicularium with triangular mandible. Ovicell raised, globular.

As already mentioned, among the 'Challenger' specimens in the British Museum marked "*crassimarginata*" there is one poor specimen which would seem to be *M. crassimarginata*, but there are a number which are quite different. They certainly, in many points, resemble the fossil from New Zealand which I called *M. Dumerilii*, Aud., but now, after seeing a number of specimens,

I should not unite it to *M. Dumerilii*: in fact it only seems separated from *M. coronata* by the avicularium not being long and winged, but short and triangular, corresponding with Hinck's first description of *M. coronata*. The avicularium of *M. coronata* is, however, set very far back, which is not the case with *M. incrustans*. It reminds us of *M. levata*, Hincks (which has since been described by MacGillivray* as *Biflustra sericea*), but that has thin walls, whereas in *M. incrustans* the walls slope inwards.

Loc. Station 135 *a*: off Inaccessible Island, Tristan da Cunha, 75 fathoms (' *Challenger* ').

Membranipora armata (*Haswell*). (Pl. 47. fig. 3.)

Biflustra armata, *Haswell*, "*On some Polyzoa from the Queensland Coast*," *Proc. Linn. Soc. N. S. Wales*, vol. v. 1880, p. 38, pl. i. fig. 7.

Membranipora panhoplites, *Ortmann*, "*Die Japanische Bryozoenfauna*," *Arch. f. Naturgesch.* 1890, vol. i. p. 28, pl. ii. fig. 4.

A specimen from Port Molle, Australia, was sent to me marked *M. nigrans*, Hincks. It is bilaminate, and on the side-walls there are numerous rosette-plates. The *M. panhoplites* of Ortmann is described and figured with the avicularia in the lower part of the cell, but it is easy to take the avicularium on the distal part of one zoœcium as belonging to the proximal part of the next; and as specimens in the British Museum from Japan marked "*M. panhoplites*" have the avicularia in the distal part, I think we may take it that this is usually the case.

Loc. Port Denison, Holborn Island, 20 fath. (*Haswell*); Port Molle; Sagamibai, 40 fath., Japan (*Ortmann*).

Membranipora hians, *Hincks*. (Pl. 48. fig. 16; Pl. 49. figs. 15, 16.)

Membranipora hians, *Hincks*, *Ann. & Mag. Nat. Hist.* ser. 5, vol. xv. p. 248, pl. vii. fig. 5.

Membranipora cyclops, *Busk*, *Cat. Mar. Polyz.* p. 61, pl. lxv. fig. 3.

The expansion of the operculum beyond the chitinous ridge (Pl. 48. fig. 16) is characteristic, and the upper part fits on to a small shelf on the distal border of the zoœcium. The *M. cyclops* of Busk has been united by various writers to several other species; but a second comparison of the British-Museum specimen

* "New or Little-known Polyzoa," pt. xiii. 1889, Proc. Roy. Soc. Vict. n. s. vol. ii. p. 107, pl. v. fig. 1.

described by Busk shows that it has this peculiar operculum and corresponds in other respects. Although Busk's name has priority, the fact that it has been impossible to recognize the species with certainty from the figure and description must be a sufficient reason for retaining the name given by Hincks. I have both unilaminate and bilaminate forms in my collection.

This is closely allied and probably identical with the fossil *M. appendiculata*, Reuss, as found fossil in Bairnsdale (Australia) and the Miocene of Europe; and in the Bairnsdale specimen there seems to be a slight shelf for the operculum. However, as we cannot be quite certain as to some of the characters of the fossil, it would seem better to retain both names for the present.

Loc. New Zealand.

MEMBRANIPORA PERMUNITA, *Hincks*.

In having the space above the avicularium unoccupied and destitute of a membrane it corresponds with *M. curvirostris*, though in having the lamina turned downwards it corresponds with *M. Savartii*, *M. bidens*, *M. patellaria*, &c., while the growth of the avicularian chamber would suggest placing it with *Onychocella*. A suggestion made in a previous paper that this species is the *M. Michaudiana*, d'Orb., cannot now be maintained.

I have a specimen in which one avicularium has a very abnormal growth, as there is a double beak to the mandible, each beak being curved in an opposite direction.

MEMBRANIPORA IMBRICATA (*Busk*). (Pl. 48. fig. 13.)

Amphiblestrum imbricatum, *Busk*, '*Challenger*' *Report*, vol. x. p. 65, pl. xv. fig. 3.

I have in my collection a bilaminate or cylindrical specimen from Port Elizabeth (S. Africa). The small pieces at first grow round a piece of seaweed, and then the growth is free and cylindrical, but perhaps as the growth increases it becomes bilaminate. The frontal lamina is turned directly downwards, much as in *M. permunita*, and the membrane in which the operculum occurs is deeply sunk at the end of the lamina. The opening of the avicularium is narrow. The rosette-plates are close to the basal wall, and there seem to be four lateral plates. *M. imbricata* does not belong to the *Chaperia* group, while "*Amphiblestrum*" *cristatum* of Busk does.

Loc. Simon's Bay, Cape of Good Hope (*Busk*); Port Elizabeth.

Onychocella angulosa (*Reuss*).

Cellepora angulosa, *Reuss, Foss. Polyp. des Wien. Tert.* p. 93, pl. xi. fig. 10.

Membranipora antiqua, *Busk, Q. Journ. Micr. Soc.* vol. vi. p. 262, pl. xx. figs. 1, 2.

Onychocella Marioni, *Jullien, Bull. Soc. Zool. France*, vol. vi. p. 7, & woodcut.

Membranipora angulosa, *Waters*, "*Bryozoa of the Bay of Naples*," *Ann. & Mag. Nat. Hist.* ser. 5, vol. iii. p. 122, pl. xiii. fig. 3; *Journ. Micr. Soc.* ser. 2, vol. v. pl. xiv. fig. 42 (mandible figured).

For other synonyms see my paper on North Italian Bryozoa, Quart. Journ. Geol. Soc. vol. xlvii. p. 9.

The mandibles are winged, having a membranous expansion at one side, and this is also the case in the forms described by Jullien as *O. Marioni* and *O. Luciæ*. The mandibles of *M. permunita*, H., *M. coronata*, H., *Foveolaria falcifera*, B., *Micropora lepida*, H., are also winged.

In the avicularium there is a round imperforate disk over the tactile organ.

There are 14 tentacles.

The presence of vicarious avicularia was made a leading character in *Semieschara* of d'Orbigny, and now vicarious avicularia are known in *M. corbula*, *M. pyrula*, *M. maderensis*, *M. longicornis*, *M. crassimarginata*, *M. papulifera*, *M. sculpta*, *M. valdemunita*, *M. permunita*, *M. velata*, *M. perfragilis*, *M. marginella*, *M. nobilis*, *M. bursaria*, var.

Loc. Living: Mediterranean, Madeira, Mauritius; Florida? Fossil: Cretaceous and Tertiary.

Membranipora perfragilis (*MacG.*). (Pl. 47. figs. 15, 16, 17.)

Biflustra fragilis, *MacGillivray*, "*Description of New Genera & Sp. of Australian Polyzoa*," 1868, *Trans. R. Soc. Vict.* vol. ix. p. 138.

Biflustra perfragilis, *MacG., Zool. Vict.* decade vi. p. 27, pl. lvii. fig. 1.

Membranipora perfragilis, *Hincks, Ann. & Mag. Nat. Hist.* ser. 5, vol. xiv. p. 278, pl. viii. fig. 4.

Membranipora crassimarginata, var. erecta, *Busk, Zool. Chall. Exp.* pt. xxx. p. 63, pl. xiv. fig. 3.

Amphiblestrum perfragile, *Ortmann*, "*Die Japanische Bryozoenfauna*," *Arch. f. Naturgesch.* vol. i. 1890, p. 29, pl. ii. fig. 5.

Membranipora perfragilis, *MacG., Tert. Polyzoa of Victoria*, p. 39, pl. v. figs. 10, 11.

It is not clear why MacGillivray changed the name *fragilis* to *perfragilis*, and it would be more strictly correct to adhere to *fragilis*.

The 'Challenger' *M. crassimarginata* var. *erecta* is clearly this species, and the distal walls have the characteristic distal rosette-plates as found in the Australian *perfragilis,* and have two lateral rosette-plates. The mounted British Museum specimens from both Stat. 162 and 151 have the avicularia as figured by Hincks in his description, but in none of the specimens in my collection do I find any, and it was first described by MacGillivray without avicularia. A poor specimen in the British Museum collected by the 'Challenger' from Nightingale Island, 135 *c*, would appear to be *M. crassimarginata*, while those from Stat. 135 *a*, Inaccessible Island, also named *M. crassimarginata* var. *incrustans*, are quite different (see *M. incrustans*, p. 686).

Ortmann describes an incrusting variety from Japan.

Loc. Bass's Straits (*MacG. & Chall.*); Port Phillip Heads (*MacG.*); Heard Island (Indian Ocean) (*Chall.*); Japan (*Ortm.*). Fossil: Muddy Creek (Victoria).

Membranipora bursaria, *MacG.*, var. phillipensis, nov. (Pl. 49. fig. 11.)

This differs from the *bursaria* of MacGillivray in having no "mammilliform process." The distal end of the calcareous lamina is arched, forming a depression at each side covered with a membrane, and it reminds us of *Micropora.* In older cells the lamina near the opercular end is more depressed and is marked off by a circular rim. The lower part of the lamina is perforated, but not the upper part. Avicularium duckbill-shaped.

Loc. Port Phillip (Victoria).

Membranipora capriensis, sp. nov. (Pl. 47. fig. 6.)

A small fragment from Capri has exceptionally large zoœcia, about 0·6–0·7 mm., and the walls are thinner and less calcified than in any species with which I am acquainted. There are no avicularia, and only on one zoœcium is there an ovicell, which is cap-like. This somewhat resembles the *M. irregularis* of d'Orbigny, but the walls are less calcified.

Membranipora elizabethiensis, sp. nov. (Pl. 47. figs. 18, 19.)

Zoarium bilaminate. Border of the zoœcia much raised, bearing one or two avicularia below the zoœcia and others on the side. The avicularia on the border are short and are closed by an obtuse triangular mandible, and there is no complete bar across the avicularium, but a tooth at each side. Frequently the avicu-

larium on the area below the zoœcium is much larger than the others and raised. The depressed opesia is nearly oval, but straighter on the lower edge, with the margins slightly crenulated. The opesia is depressed in the same way in *M. occultata*, Waters, *M. hians*, Busk, &c. The solid ovicell is not much raised, and an area is marked off by a line near the distal end. There are numerous distal rosette-plates and eight lateral ones.

This is very closely allied to *M.* (*Foveolaria*) *tubigera*, B., as in both the opesial opening is in size and shape about the same; there are in both numerous small avicularia, and frequently a large one below the opesia. The broad smooth ovicell is similar in both, as are also the lateral and distal rosette-plates, but in the present species the lateral tube ("articulated process") is wanting, and no trace of any such structure has been found. In *M. tubigera* there is on the border, opposite to the tube, an irregular process, which is wanting in the *M. elizabethiensis*, though sometimes the border carries small irregular elevations. The general appearance varies much between the older and younger zoœcia.

Loc. Port Elizabeth.

Membranipora tripunctata, *Waters*. (Pl. 49. fig. 18.)

Membranipora tripunctata, *Waters, Quart. Journ. Geol. Soc.* vol. xxxviii. p. 262, pl. ix. fig. 35; *Ann. & Mag. Nat. Hist.* ser. 5, vol. xx. p. 184, pl. v. figs. 12, 18, 19, 20.

I am now able to give a more satisfactory figure of this species, through having made an examination of a specimen boiled in caustic potash. The spaces above the zoœcium are avicularian chambers. This was first described from a small fossil specimen, of which the state of preservation was not very good, and as soon as others are found they should be examined in order to test whether I was right in uniting the recent and fossil forms.

Loc. "N.E. Australia"; Holborn, Broughton, and Fitzroy Islands (Queensland).

EXPLANATION OF THE PLATES.

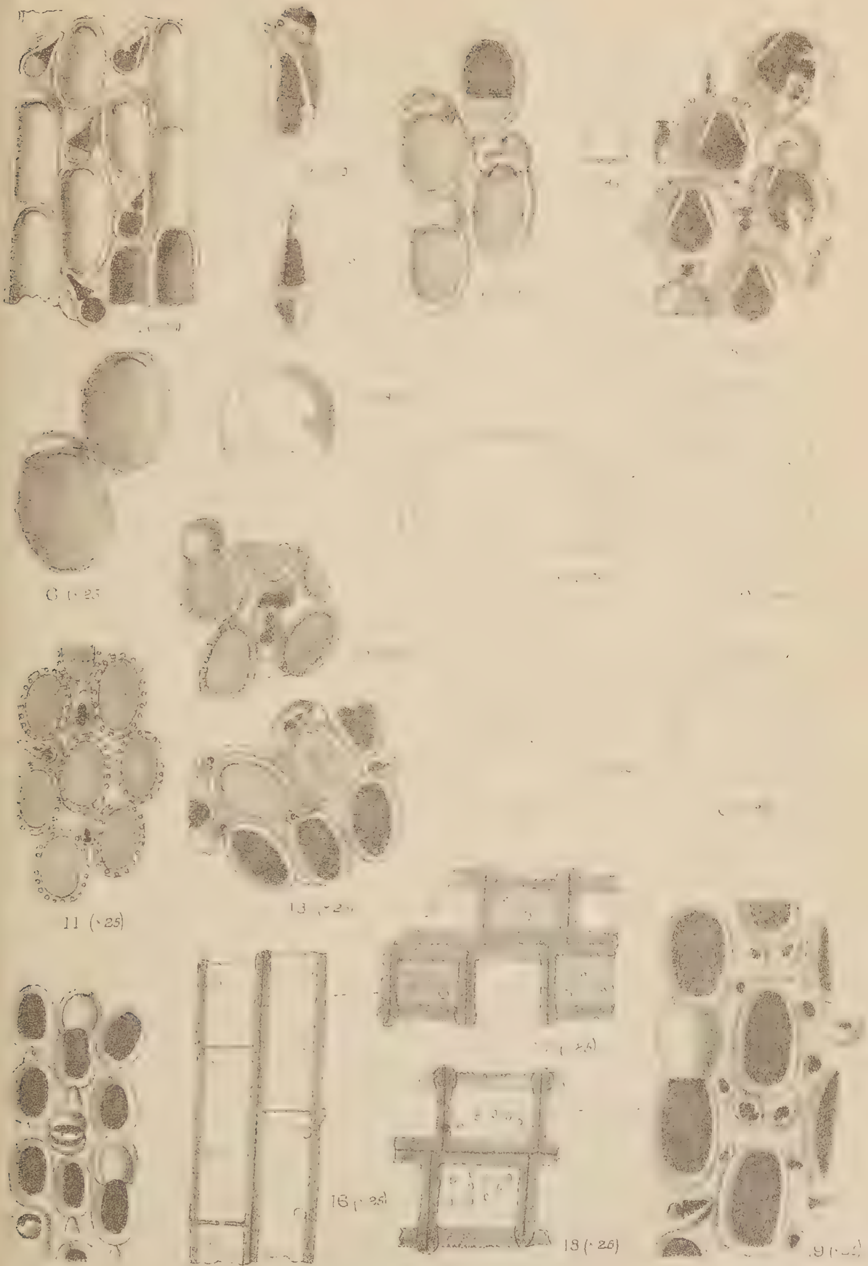
Plate 47.

Fig. 1. *Membranipora gregaria*, Heller. × 25.
2. *Membranipora curvirostris*, Hincks. Avicularia. × 50.
3. *Membranipora armata*, Haswell. Avicularia. × 50.
4. *Membranipora crassimarginata*, Hincks. Naples. × 25.

Fig. 5. *Chaperia annulus*, Manz., var. *bilaminata*, nov. × 25.
5A. Do. Mandible. × 85.
6. *Membranipora capriensis*, sp. nov. × 25.
7. *Membranipora tenuirostris*, Hincks. Operculum.
8. *Chaperia annulus*, Manz., var. *bilaminata*, nov. Operculum to ovicell. × 85.
9. Do. Operculum to zoœcium. × 85.
10. *Chaperia acanthina*, Quoy & Gaimard. Operculum. × 85.
11. *Membranipora lineata* (L.) 'Challenger' Station 75, Azores. One of the specimens described as *M. albida*. ×25.
12. *Membranipora curvirostris*, Hincks, var. 'Challenger' Station 172, Nukalofa. The other specimen described as *M. albida*. × 25.
13. *Membranipora incrustans*, nom. nov. 'Challenger' Station 135 *a*, Inaccessible Island. Described as *Membranipora crassimarginata*, var. *incrustans*. ×25.
14. *Membranipora sculpta*, MacG., var. *cucullata*, nov. × 25.
15. *Membranipora perfragilis*, MacG. Avicularian mandible. × 85.
16. Do. Lateral wall showing rosette-plates. × 25.
17. Do. Distal wall showing rosette-plates. × 25.
18. *Membranipora elizabethiensis*, sp. nov. Distal rosette-plates. × 25.
19. Do. × 25.

Plate 48.

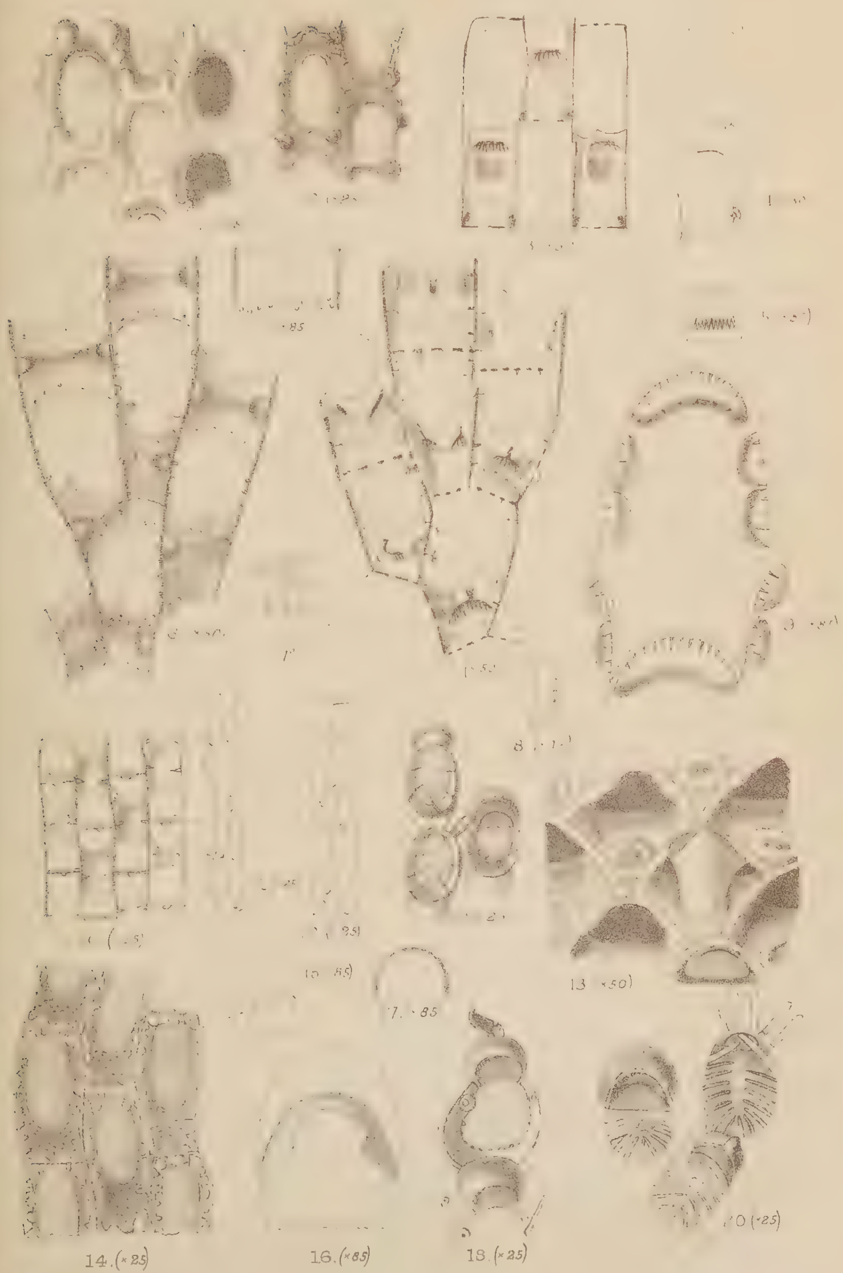
Figs. 1, 2. *Membranipora tehuelcha*, d'Orb., var. *intertuberculata*, nov. × 25.
Fig. 3. *Membranipora nitens*, Hincks. Dorsal view, interior surface, showing comb-like process. × 50.
4. Do. Lateral view. × 50.
5. Do. Comb-like process. × 50.
6. *Membranipora tehuelcha* (d'Orb.). From Angola. Front view. × 50.
6A. Do. Distal wall, showing rosette-plates. × 85.
7. Do. Dorsal view, interior, showing spines. × 50.
7A. Do. Spine more magnified.
8. Do. Lateral rosette-plates. × 12.
9. *Membranipora lineata*, L. Dorsal surface, showing distal and lateral pore-chambers, with spines within the chambers. × 85.
10. *Flabellaris roborata* (Hincks). Dorsal surface. × 25.
11. Do. Lateral view, showing rosette-plates. × 25.
12. *Menipea triseriata*, Busk. Do. × 25.
13. *Membranipora imbricata* (Busk). From Port Elizabeth. Showing the "hatchet-shaped avicularian process" over one zoœcium; the others are broken away, and the two rosette-plates into the avicularian chamber are seen. × 50.
14. *Membranipora Lacroixii*, Aud. Dorsal surface. × 25.
15. Do. Operculum. × 85.
16. *Membranipora hians*, Hincks. Operculum. × 85.
17. *Membranipora membranacea*, L. Operculum. × 85.



A W W. del. A T Hollick lith.

West Newman imp.

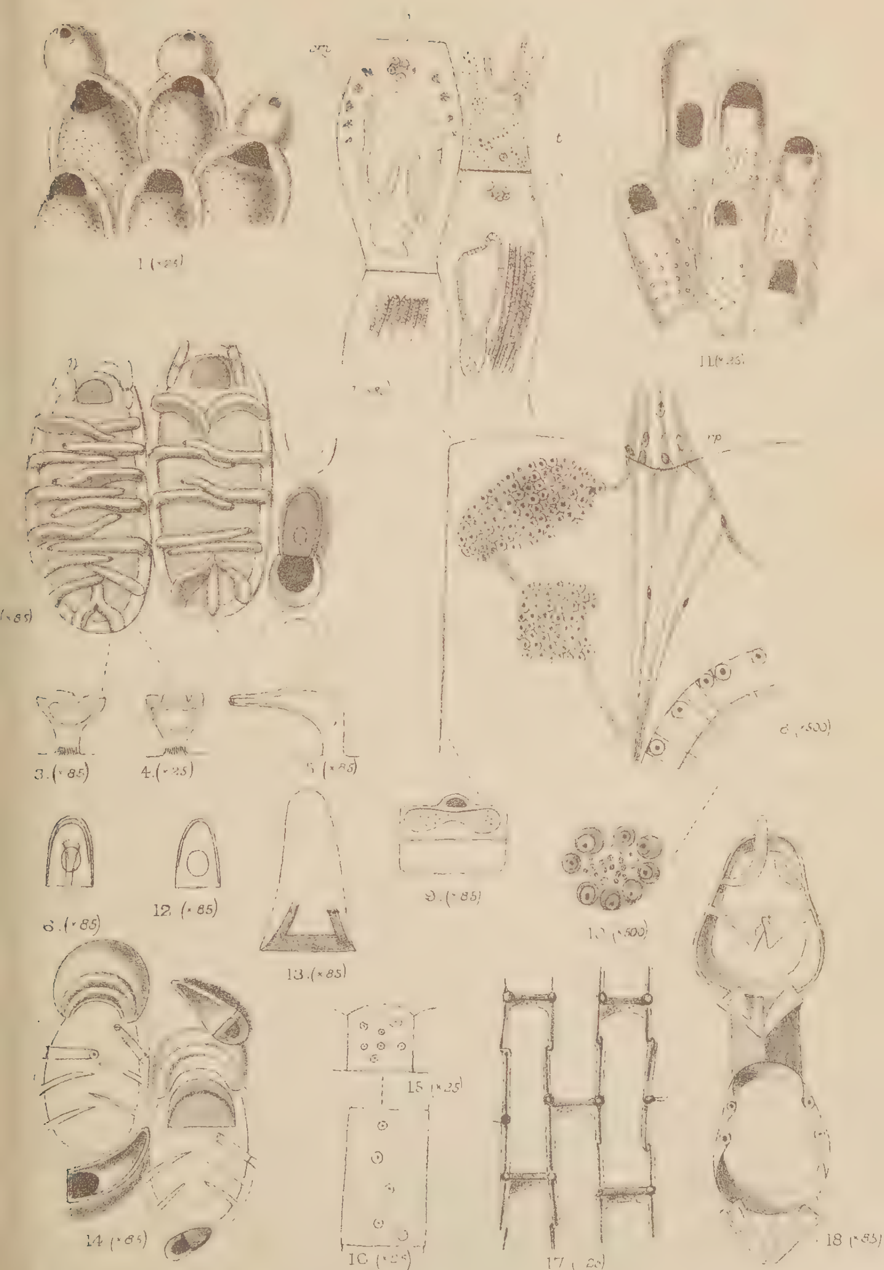
MEMBRANIPORIDÆ.



A. W. W. del. A. T. Hollick lith.

West, Newman imp.

MEMBRANIPORIDÆ.



A WW del. A T Hollick lith. West Newman imp

MEMBRANIPORIDÆ.

Fig. 18. *Membranipora armifera*, Hincks. From the Gulf of St. Lawrence. × 25.

19. *Membranipora maderensis*, sp. nov. Showing vicarious avicularium. × 25.

20. *Membranipora corbula*, Hincks. Do. × 25.

Plate 49.

Fig. 1. *Membranipora bidens* (Hag.). From Capri. × 25.

2. *Membranipora sceletos*, Busk. × 85.

3, 4. Do. Spinous plates by the side of the oral aperture. × 85.

5. Do. Frontal spine seen from the side. × 85.

6. Do. Mandible. × 85.

7. *Flabellaris roborata* (Hincks). Section showing the position of the ovarium (*o*) and of the cellular masses (*c.m.*). × 85.

8. Do. Cellular masses and the parenchym-threads attached to these passing through a rosette-plate (*r.p.*), and also attached to the walls of the stomach. × 500.

9. Do. Distal rosette-plate. × 85.

10. Do. Ovarium. × 500.

11. *Membranipora bursaria*, MacG., var. *phillipensis*. × 85.

12. *Membranipora flustroides*, Hincks. Mandible. × 85.

13. *Membranipora pyrula*, Hincks. Mandible. × 85.

14. *Membranipora californiensis*, sp. nov. ×85.

15. *Membranipora hians*, Hincks. Distal rosette-plate. × 25.

16. Do. Lateral rosette-plate. × 25.

17. *Membranipora membranacea*, L. Showing breaks in the side wall. × 25.

18. *Membranipora tripunctata*, Waters. × 85.

INDEX.

[Synonyms and native names are printed in *italics*. A star is added to names which appear to be here used for the first time.]

END OF THE TWENTY-SIXTH VOLUME.

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